

# Temperature Control of Prehospital Medications:



*“Who’s Burning Who??”*

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## Reality Check

- "Instead of getting married again, I'm going to find a partner I really don't like and just give her a house." Steven Seagal
- "The problem with the designated driver program, it's not a desirable job. But if you ever get sucked into doing it, have fun with it. At the end of the night, drop them off at the wrong house." Jeff Foxworthy
- "Why does Sea World have a seafood restaurant? I'm halfway through my fish burger and I realize, "Oh, my Goodness... I could be eating a slow learner." Lynda Montgomery
  - "Relationships are hard. It's like a full time job, and we should treat it like one. If your boyfriend or girlfriend wants to leave you, they should give you two weeks' notice. There should be severance pay, and before they leave you, they should have to find you a temp." Bob Ettinger
  - "My Mom said she learned how to swim when someone took her out in the lake and threw her off the boat. I said, 'Mom, they weren't trying to teach you how to swim.' Paula Poundstone

The use of medications in the out-of-hospital environment may benefit certain patients:

Asthma

Seizures

Hypoglycemia

??Cardiac Arrest???

??Arrhythmia??



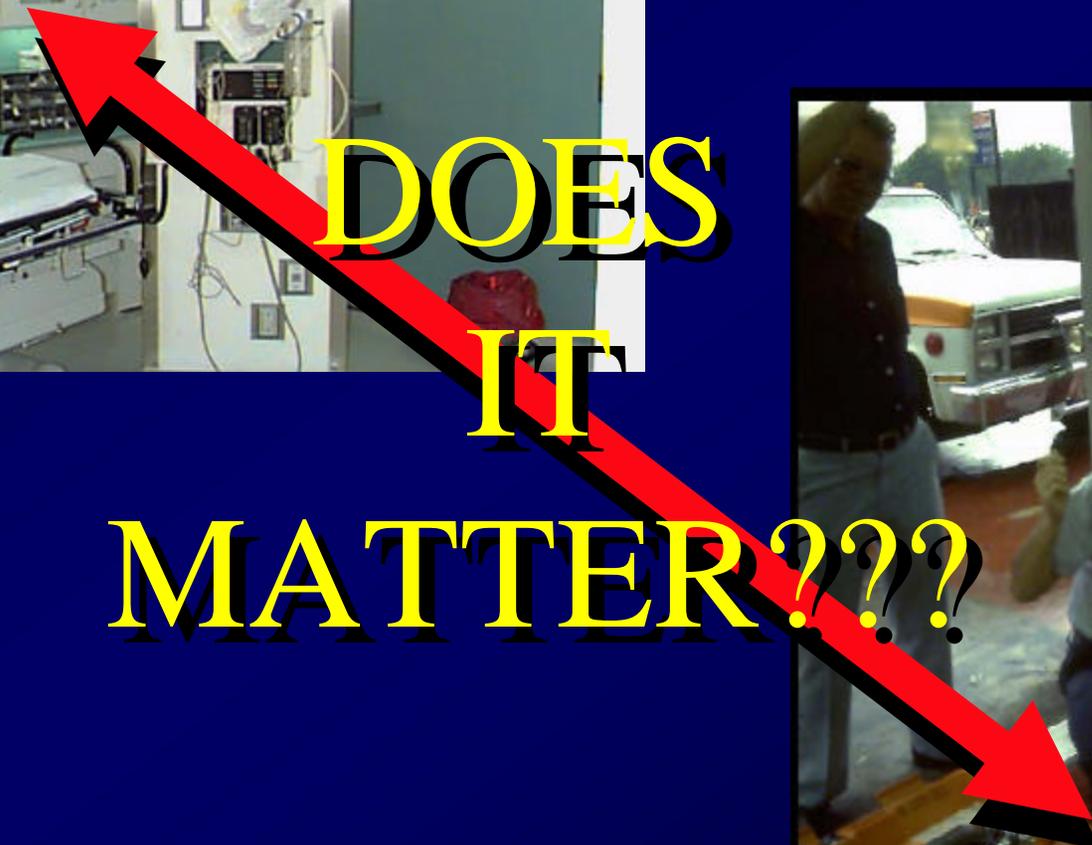


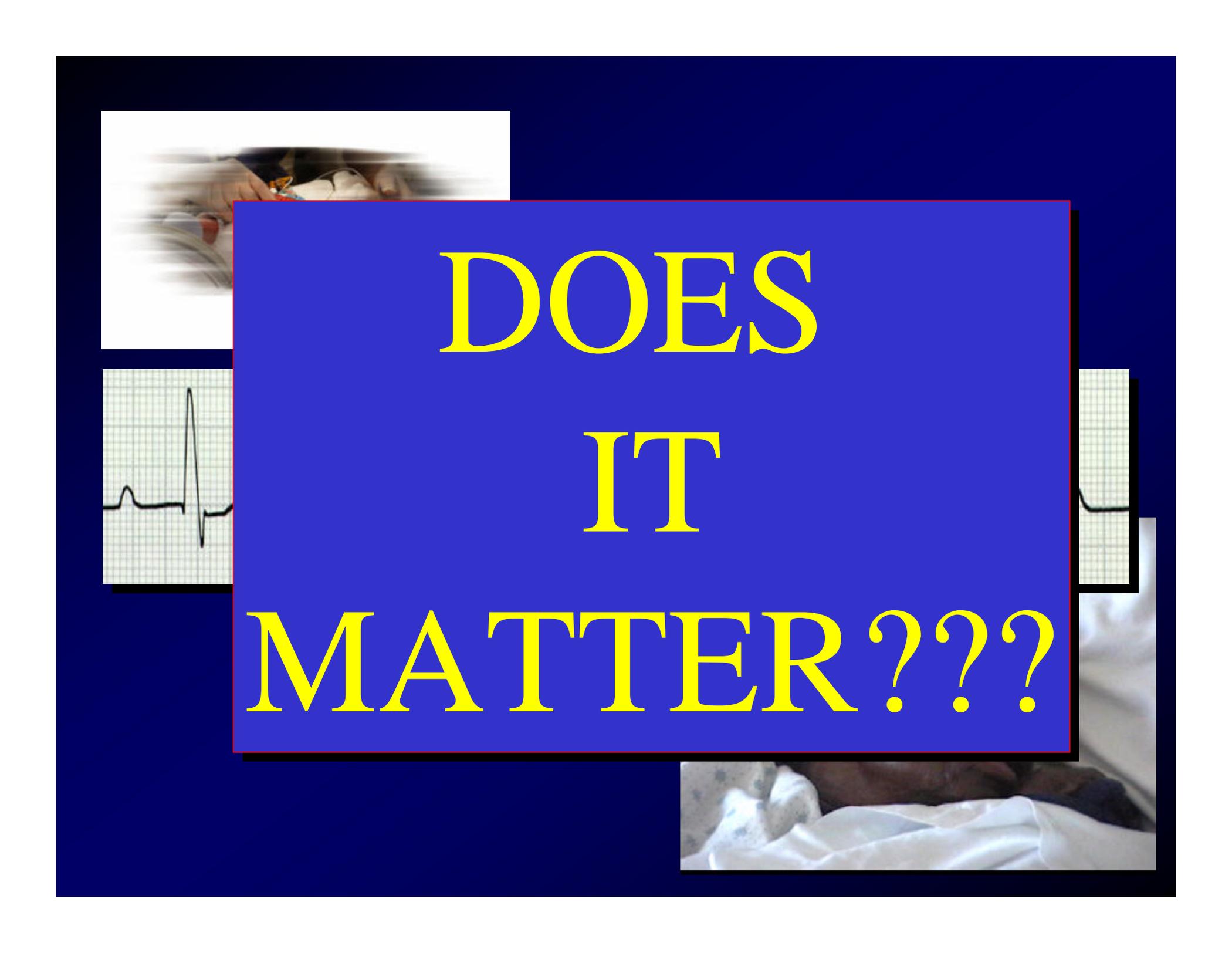
What is clear is that the environment that medications are being taken into is different from an in-house pharmacy





**DOES  
IT  
MATTER???**





DOES  
IT  
MATTER???



Revisions in the standards of the United States Pharmacopeia (USP) related to product dating, packaging, and temperature monitoring are discussed. USP has revised product dating specifications as they relate to pharmacy practice.

**“Revised USP standards for product dating, packaging, and temperature monitoring.”**

Okeke CC, Bailey L, Medwick T, Grady LT

*Am J Health Syst Pharm* 2000 Aug 1;57(15):1441-5

“A drug is deemed to be adulterated if the methods used in or the facilities or controls used for the drug’s manufacture, processing, packing or holding do not conform to or are not operated or administered in conformity with good manufacturing practice to assure that such drug has the identity and strength, and meets the quality and purity characteristics which such drug purports or is represented to possess...”

21 USCA 351(a)(2)(b) – 351 (c)

The United States Pharmacopeia and  
National Formulary (USP 24/NF19, 2000)

USP requires that the pharmacy facility where dispensing or repackaging occurs be maintained at controlled room temperature such that the calculated mean kinetic temperature does not exceed 25 degrees C.

**Controlled Room Temperature** – A temperature maintained thermostatically that encompasses the usual and customary working environment of 20 – 25 degrees C (68 – 77 degrees F) that results in a mean kinetic temperature calculated to be not more than 25 degrees, and that allows for excursions between 15 and 30 degrees C (59 and 86 degrees F) that are experienced in pharmacies, hospitals, and warehouses.

$$\text{MKT} \equiv T_k - 273.2$$

$$- 10,000$$

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$$\ln (e^{-10,000} + e^{-10,000} + \dots + e^{-10,000} + e^{-10,000})$$

-----  
 $T_{1H}$   
 -----

-----  
 $T_{1L}$   
 -----

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 $T_nH$   
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-----  
 $T_nL$   
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$$2n$$

# **Drug Adulteration**

## **In Prehospital Emergency Medical Services**

*A Report of Findings in Science, Practice, Law and Government*

Robert C. Kellow  
Carter L. Ferguson, JD  
Wade N. Spruill, Jr.

October 1994

Concern over the de-stabilizing effects of temperature extremes on prehospital drugs was first reported in 1985.<sup>4</sup> The Palmer study found that temperatures encountered in the prehospital setting are far more extreme than those required for safe drug storage. Further, excessive medication temperatures are sustained, disproportionate to their ambient environment. The study did not report the effects of extreme cold conditions or prehospital exposure to sunlight and humidity. It did suggest that drugs used in the prehospital setting are being chemically altered as a result of the unclimatized storage conditions that are indigenous to the EMS setting.

Subsequent studies reported results that appear to be associated with the length of exposure to temperature extremes. One study reported an 11 percent loss of parent isoproterenol and changes in the ionized state of epinephrine after four weeks of exposure to extreme heat.<sup>5</sup> Another showed no changes in the drugs tested when subjected to 16 hours of variable temperature extremes.<sup>6</sup> No studies conducted to date have attempted to determine the remaining bioactivity in drugs subjected to temperature extremes.

Investigation into the effects of excessive temperatures on drugs is not limited to the United States. In 1991, Hogerzen, et al. reported the effect of temperature extremes on a consignment of drugs that was shipped from the Netherlands to the Nile Province Essential Drugs Project in Sudan. They were subsequently transferred to the Central Medical Stores in Khartoum. An analysis of their potency

**“Prehospital storage degrades  
the physiological effects of epinephrine  
in human myocardium”**

Cairns CB, Cain BS et al  
**Annals of Emergency Medicine**  
[ACEP Research Forum Abstracts],  
1999 Oct, Part 2, 34(4)

Constant (169 total hours of heat exposure) heating resulted in complete degradation of both compounds (epinephrine) and dark brown discoloration of the solution. Cyclical heating (672 total hours of heat exposure) resulted in a 31% reduction in EPI concentration and a 225% increase in EPI-SA concentration with no discoloration of the solution

*Am J Emerg Med 1994 May;12(3):306-9*

Thermal degradation of injectable epinephrine.

Church WH, Hu SS, Henry AJ

Department of Chemistry, East Carolina University, Greenville, NC 27858.

# Prehospital Stability of Diazepam and Lorazepam

Gottwald, PharmD, Akers, MS, and Liu, MD  
American Journal of Emergency Medicine,  
Volume 17, #4; 333-337

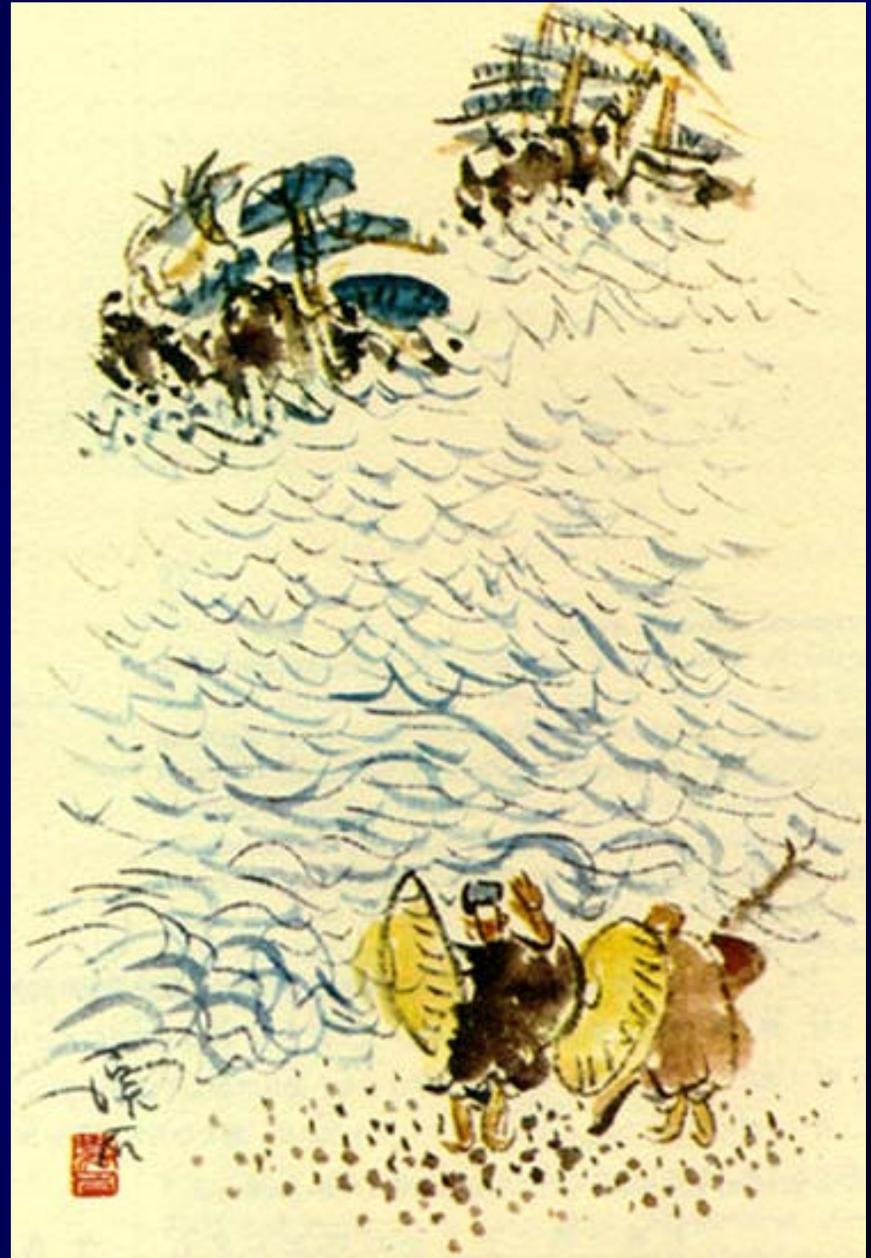
Department of Clinical Pharmacy, University of California  
San Francisco, CA

# Prehospital Stability of Diazepam and Lorazepam

Subjected samples of Valium and Ativan to temperatures ranging from refrigeration to 37 degrees centigrade (98.6 fahrenheit) for periods up to 210 days

Samples were analyzed at 30 day intervals using HPLC analysis

The degradation of Valium is accompanied by the appearance of a yellow color produced by a “benzophenone derivative”



“When the ambient storage temperature is 30 degrees or less, ambulances carrying Ativan and Valium should be restocked every 30 to 60 days.

When drug storage temperatures exceed 30 degrees C, more frequent stocking or refrigeration is required.”

Gottwald et al “Stability of Diazepam and Lorazepam”



The degradation of drugs carried in EMS drug boxes produces breakdown products the effects of which cannot be predicted.

“The results indicate that drug storage temperatures in some prehospital rescue vehicles exceed USP guidelines. Mechanical cooling of the storage compartment results in drug storage temperatures within the USP guidelines. Mechanical cooling of drug storage compartments on vehicles is technologically and financially possible.”

*J Emerg Med* 2000 Apr;18(3):345-8

Drug storage temperatures in rescue vehicles.  
DuBois WC

**“This study demonstrates that out-of-hospital medications are subject to temperatures both above and below recommended storage temperatures. Time-temperature indicator labels can reliably monitor exposure to elevated temperatures.”**

*Acad Emerg Med* 1999 Nov;6(11):1098-103

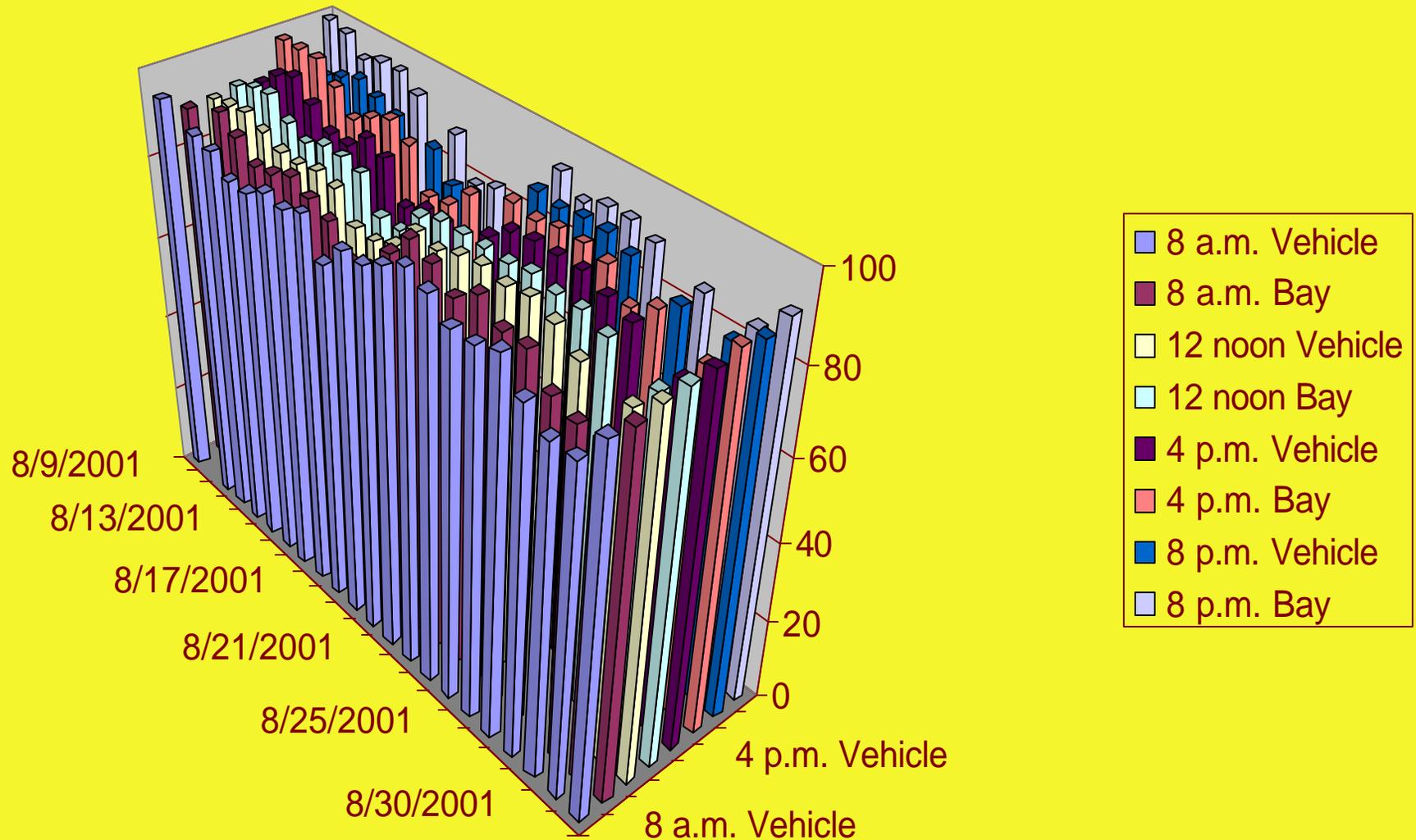
**Storage temperatures of out-of-hospital medications.  
Allegra JR, Brennan J, Lanier V, Lavery R, MacKenzie B**



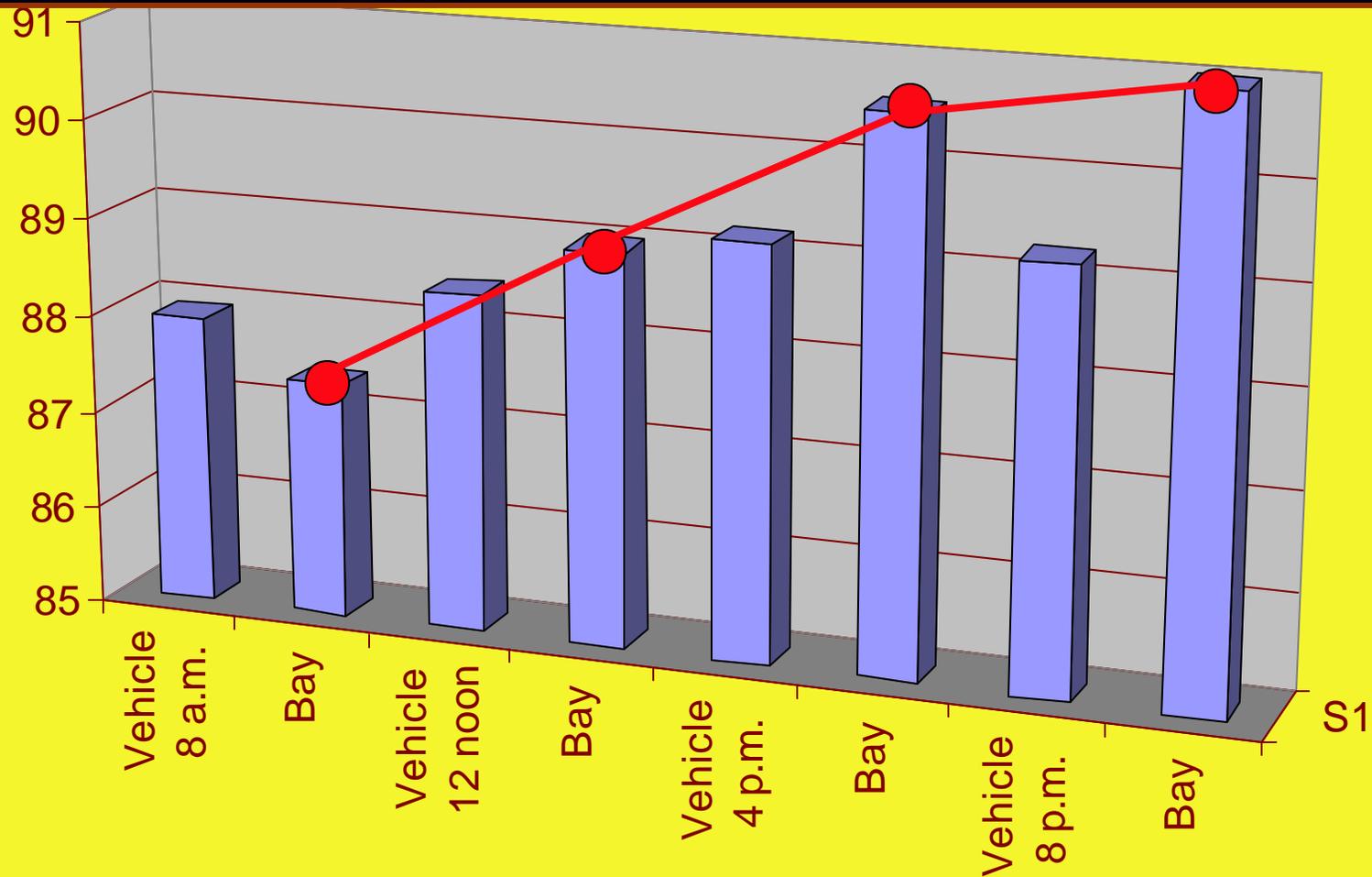
FOR SALE  
OSAMA  
BIN  
LADEN  
SWING SET



# Metro-Dallas Ambulance Temperature Study, August 2001

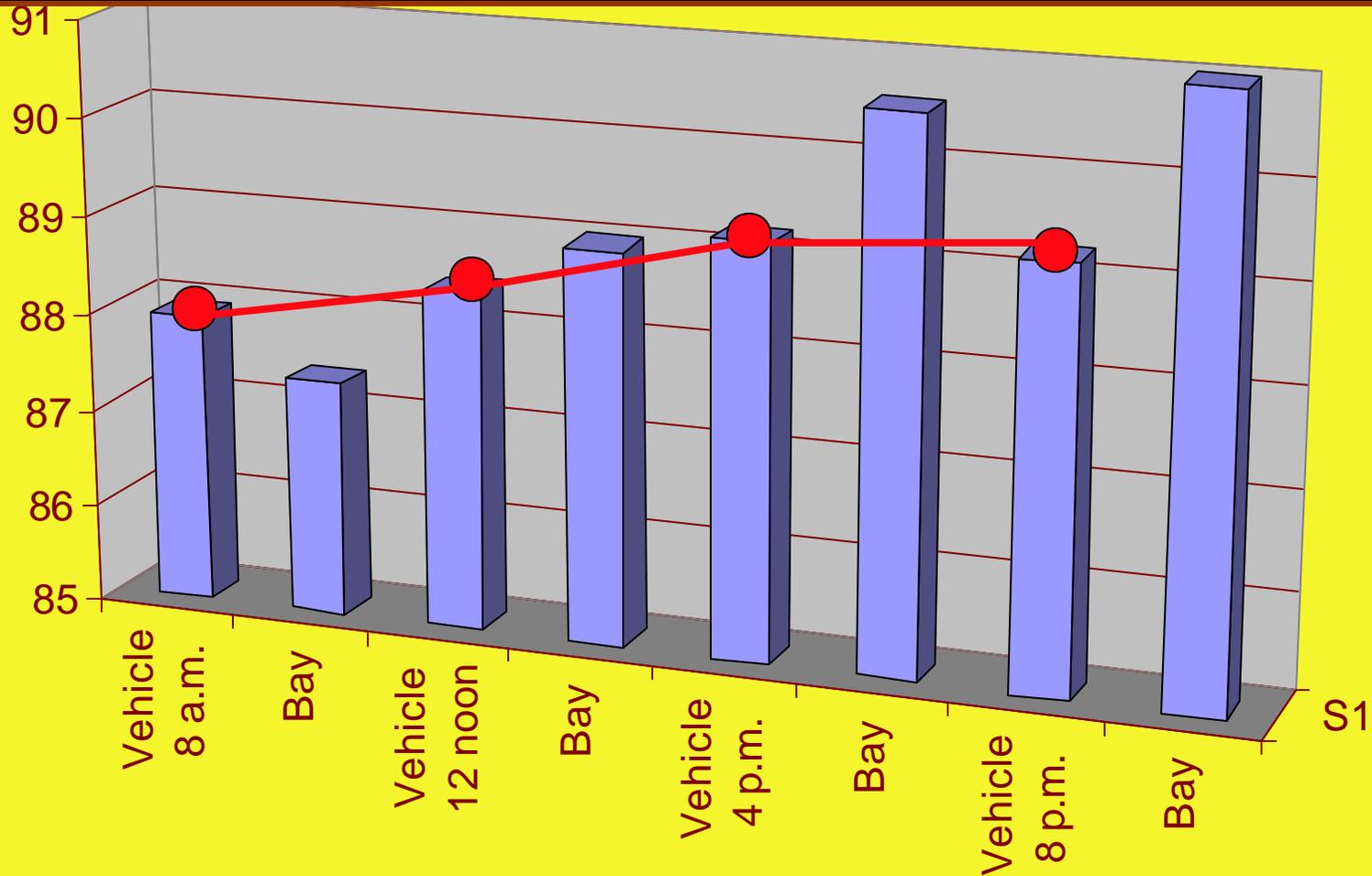


# Bay Temperatures Showed a Steady Rise During the Summer Texas Heat

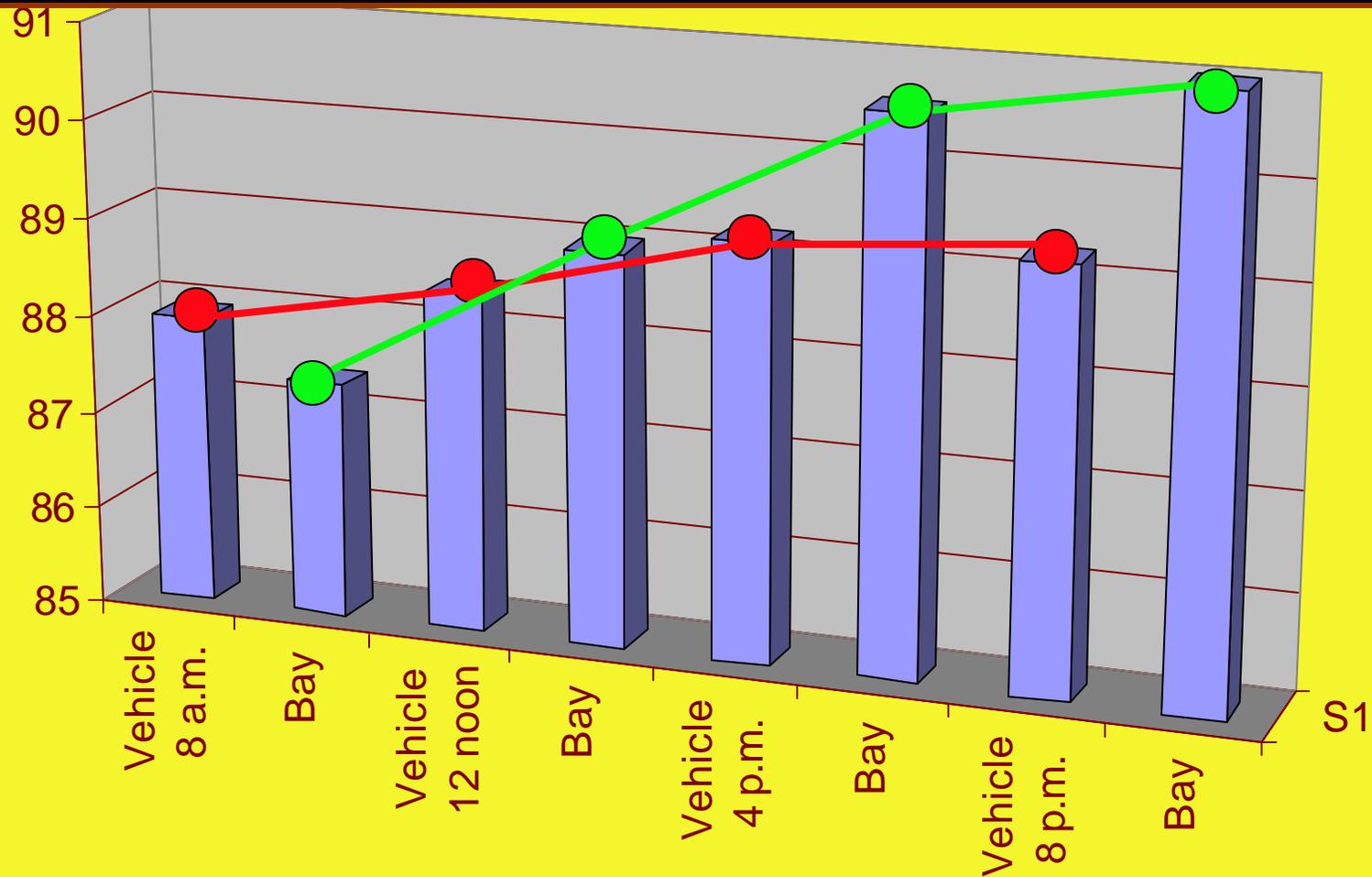


S1

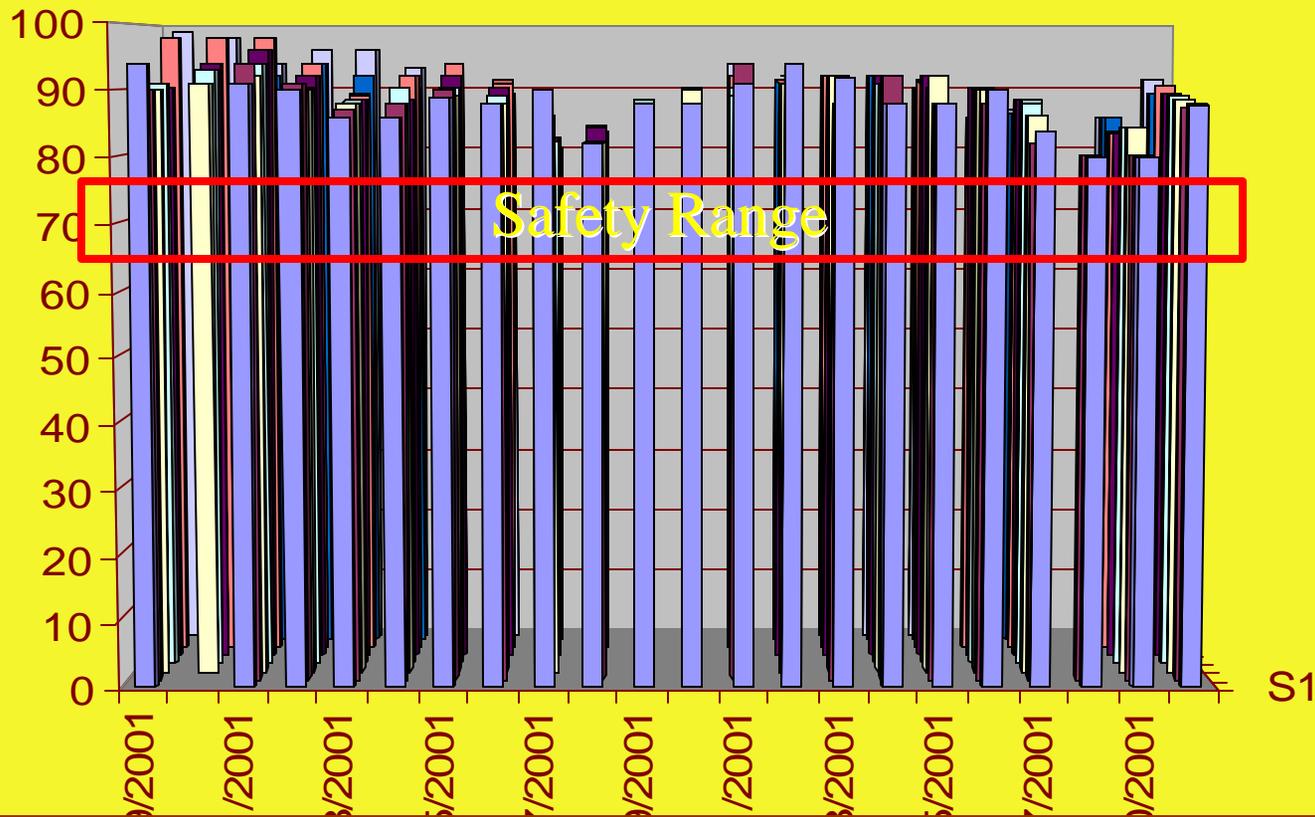
# Drug box temperatures showed a more gradual and less extreme rise



# Comparison shows the greater temperature change on the Bay

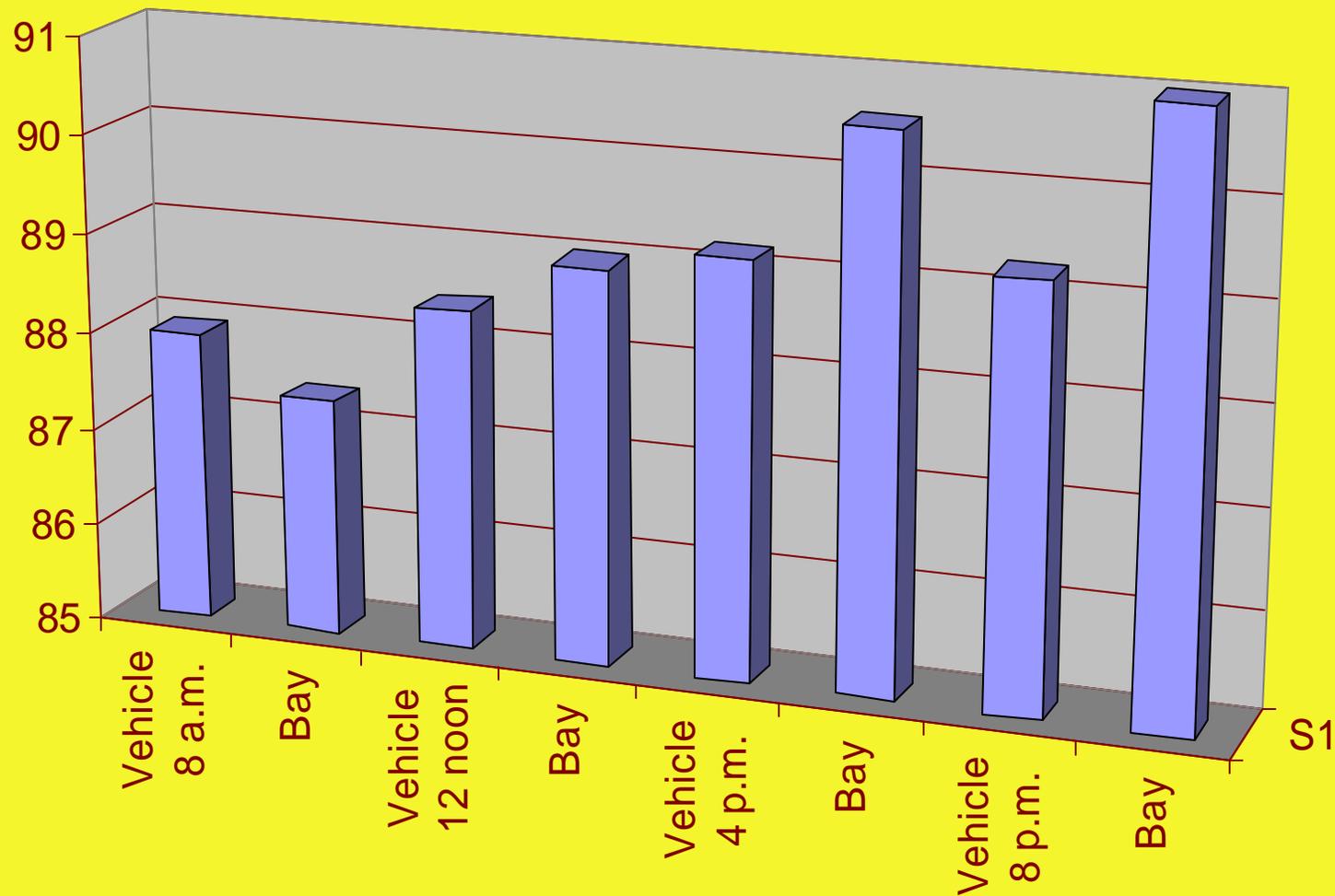


At all times, and in all measurements...

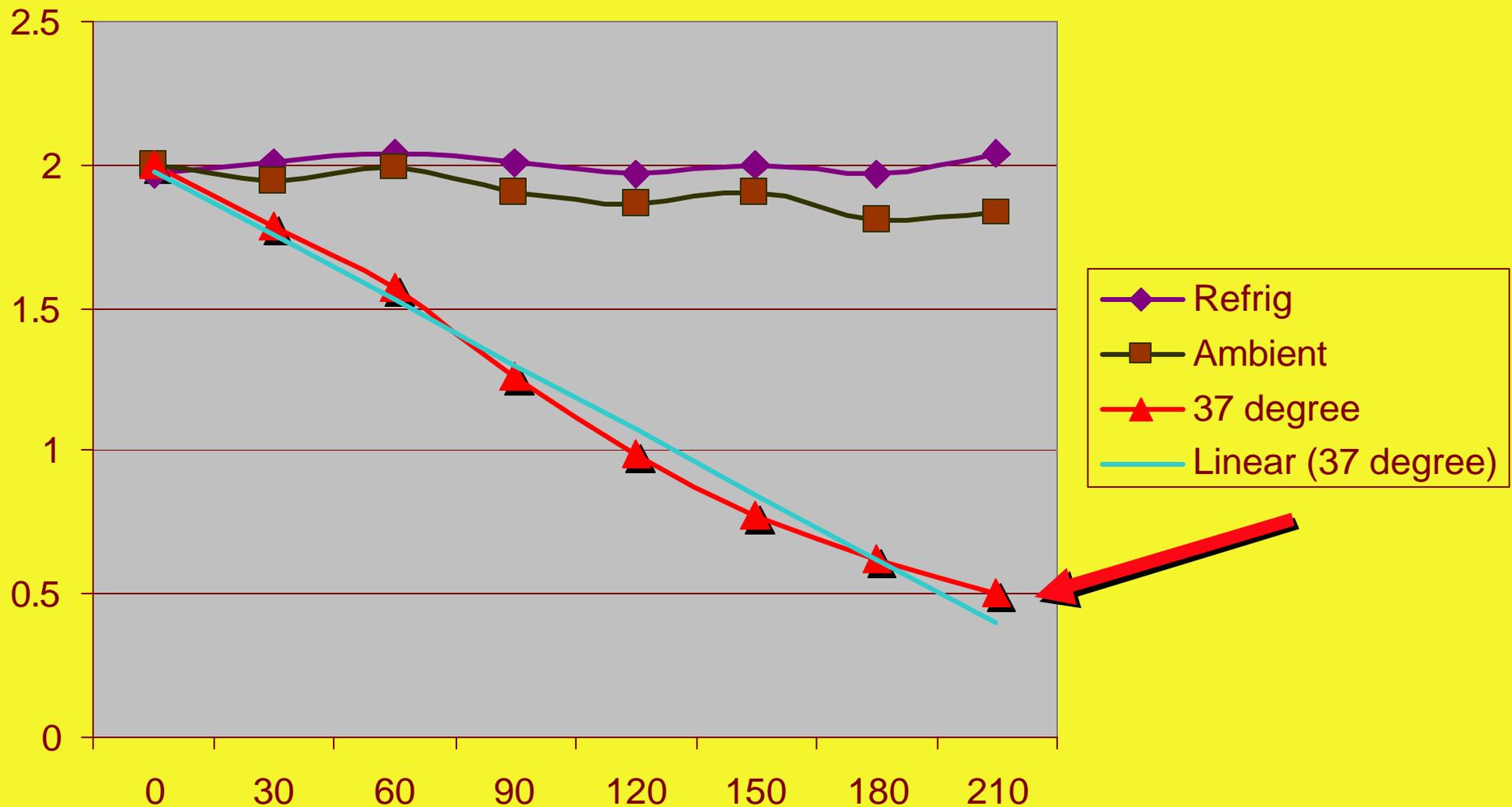


...temperatures exceeded recommended storage temperatures

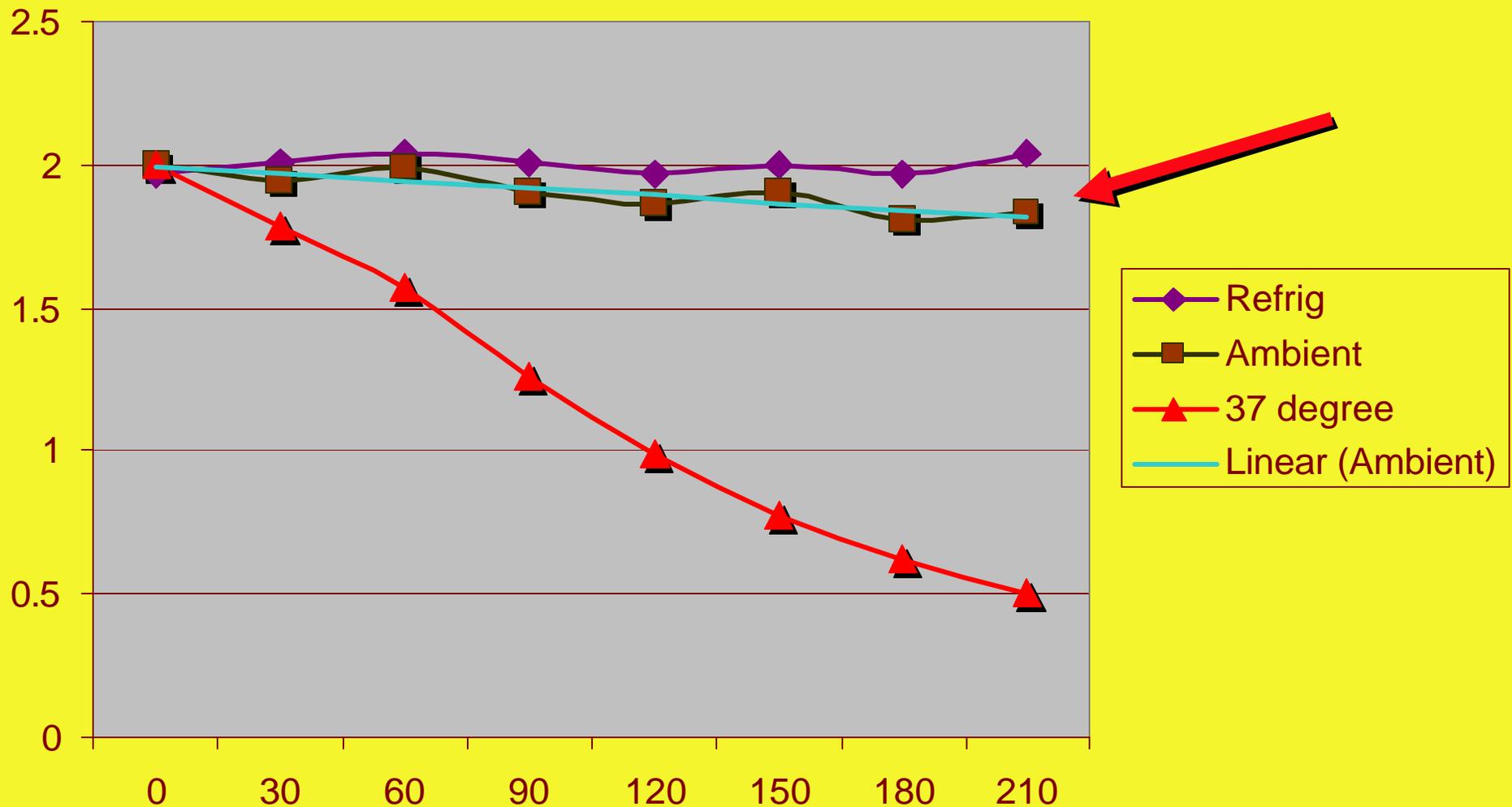
# Average Temperatures Exceeded the safe range at all times



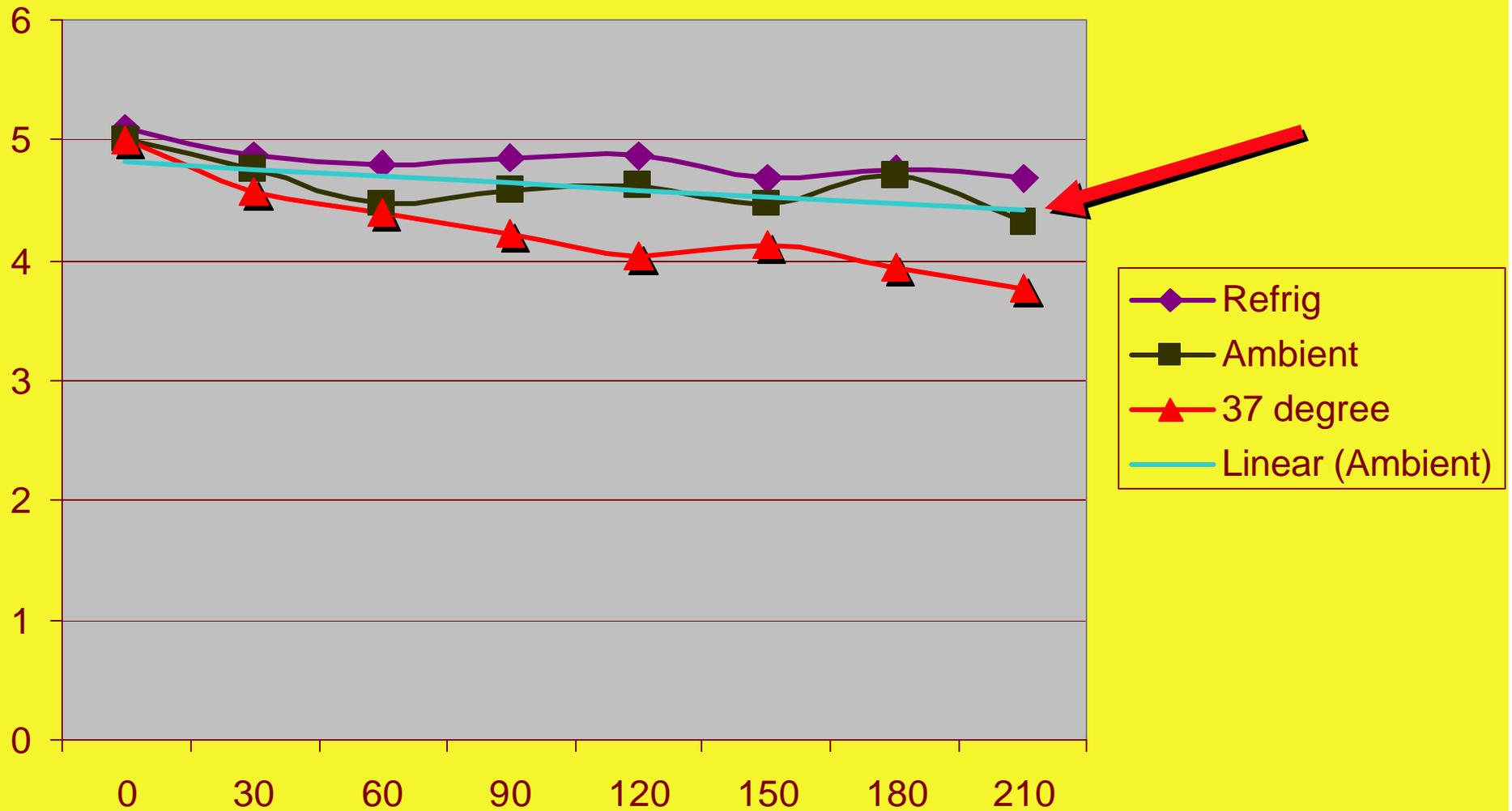
# 75% degradation of Ativan in the ambient temperatures of Texas



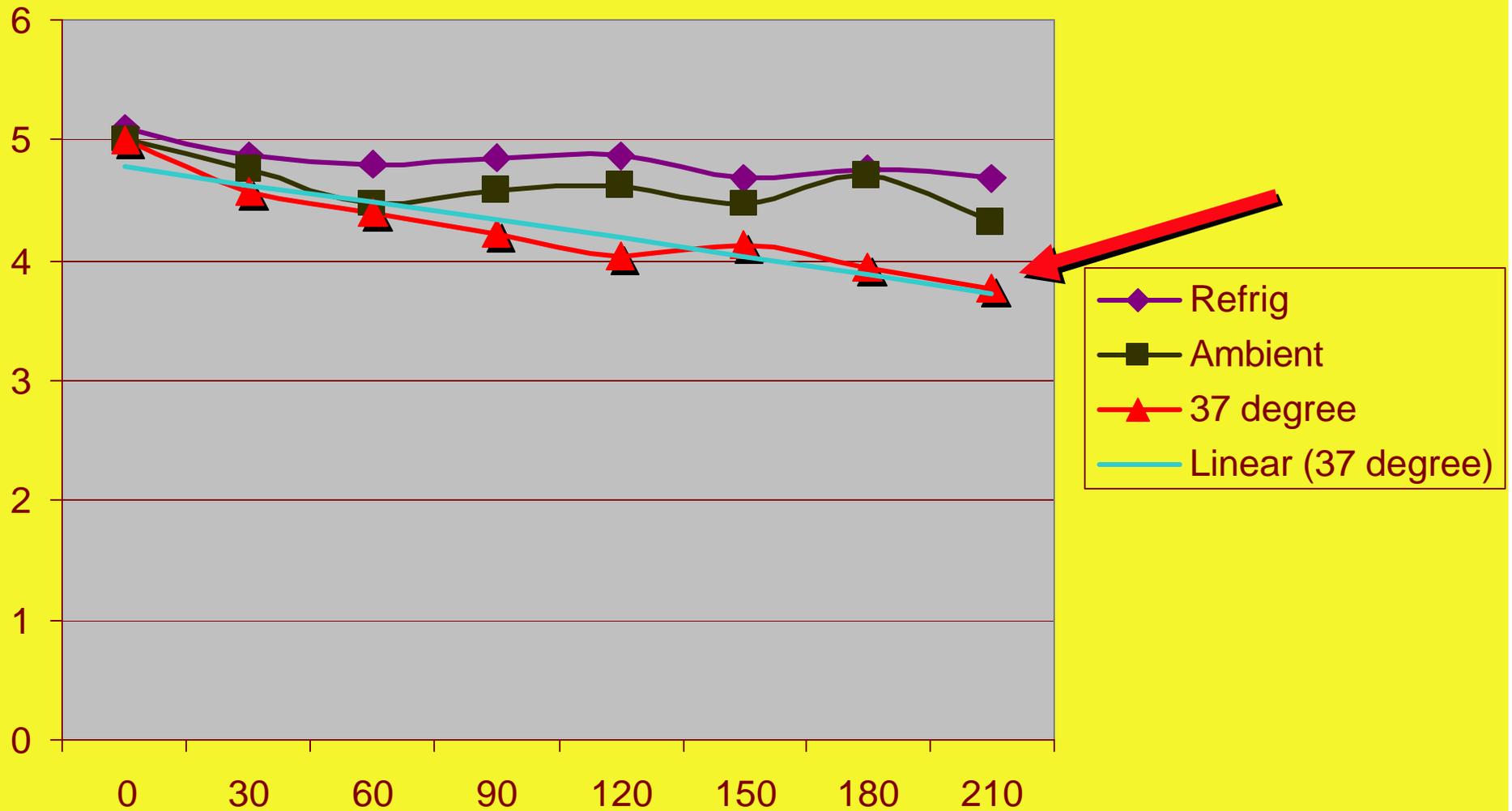
# Almost no degradation of Ativan in the ambient temps of San Francisco



# 15% degradation of Valium in the ambient temperatures of San Francisco



# 25% degradation of Valium in the ambient temperatures of Texas



# The Simple Reality:

It has been shown time and again that EMS drugs are regularly subjected to temperatures outside of recommended storage recommendations.

**EMS Drugs are adulterated!!**

# UNMEASURABLE OUTCOMES

*Does it really make a  
difference?*

Does receiving only a half milligram  
of Ativan, or only three  
milligrams of Valium make a  
potential difference in the  
seizure patient?

Does receiving only a half milligram  
or even a fourth of a milligram  
of epinephrine instead of  
a whole milligram make a  
difference in the setting of  
cardiac arrest?

Does receiving dosages of  
butyrophenones and  
epinephrine-sulfonic acid  
cause toxic effects in the human?

Are we not administering  
unprescribed chemicals when  
we give drugs that have,  
or may have,  
breakdown products  
in the fluid?

Even if we change out drug boxes  
once a week –

**OR EVEN DAILY –**

**THE MEDICATIONS ARE  
STILL ADULTERATED!!**

## Reality Check, continued

- "The day I worry about cleaning my house is the day Sears comes out with a riding vacuum cleaner." Roseanne
- "I think that's how Chicago got started. A bunch of people in New York said, 'Gee, I'm enjoying the crime and the poverty, but it just isn't cold enough. Let's go west.'" Richard Jeni
- "If life was fair, Elvis would be alive and all the impersonators would be dead." Johnny Carson
- "Sometimes I think war is God's way of teaching us geography." Paul Rodriguez
- "My parents didn't want to move to Florida, but they turned sixty, and that's the law." Jerry Seinfeld
- "In elementary school, in case of fire you have to line up quietly in a single file line from smallest to tallest. What is the logic? Do tall people burn slower?" Warren Hutcherson
- "Bigamy is having one wife/husband too many. Monogamy is the same." Oscar Wilde



**NO POSITION**

# Organized Medicine in General

**NO POSITION**



**WHEELED COACH** *Delivers...*

800-422-8206



***...CAN YOU CALL BACK AFTER LUNCH??***



**SOLUTIONS??**

For  
Food &  
Coolers



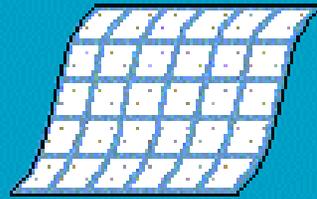
PORTABLE TEMPERATURE PADS

COOL 'EMS

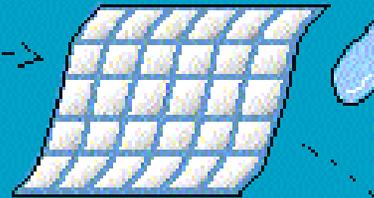
HEAT 'EMS



Dry **Cool'Ems/Heat'Ems**



Hydrated **Cool'Ems/Heat'Ems**



0-10°F

Use **'Em** Cold



Flexible



140-160°F

Use **'Em** Hot



Reusable

Adaptable



**CFE Medical Products**

**Laramie Wyoming**

**fcylvick@drugcase.com**

**\$495 - \$715**

**17 x 16 x 7H**

**21 x 16 x 16H**

**21 x 16 x 21H**



Very reliable sensors and electronics control the thermoelectric heat pump to assure the MC-2000 drug case will keep medications in the recommended storage temperature range of 59 - 86 degrees F (15 - 30 degrees C) in ambient temperatures ranging from 20 - 120 degrees F (-8.7 - 48.9 degrees C).

- Solid state controls - no moving parts
  - Very quiet brushless fan
  - Adjustable temperature set point
- Operates with any 12 VDC vehicle power
  - or 110 VAC with optional power adapter
- Internal storage temperature displayed on digital panel



**MC-2000 has FDA approval to market.  
(according to the manufacturer)**



**Direct Quotes**  
**from National Salespersons**  
**American Emergency Vehicles**  
**Matrix**

*February 8, 2002*

“No demand”

“Very new”

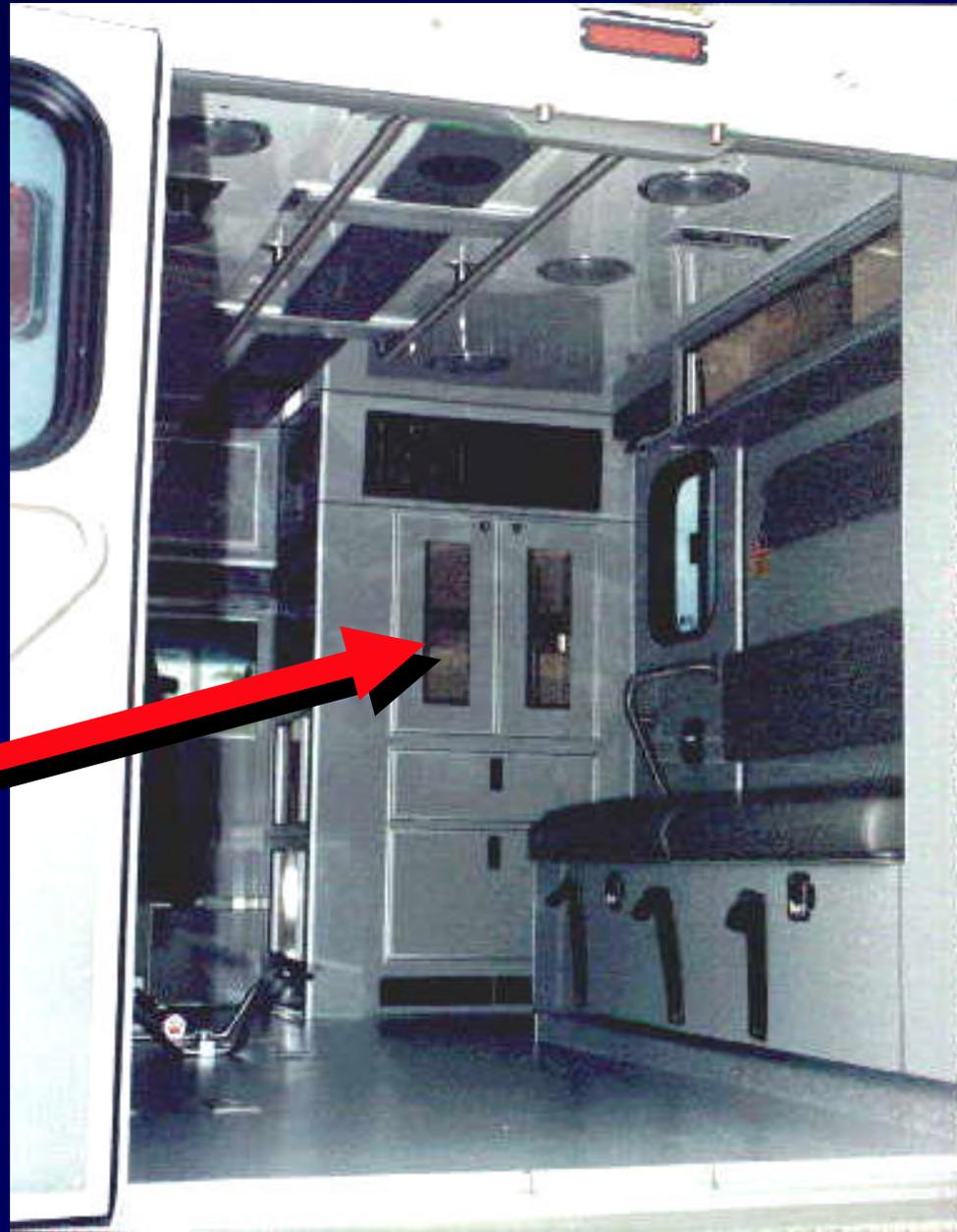
“No orders for them”

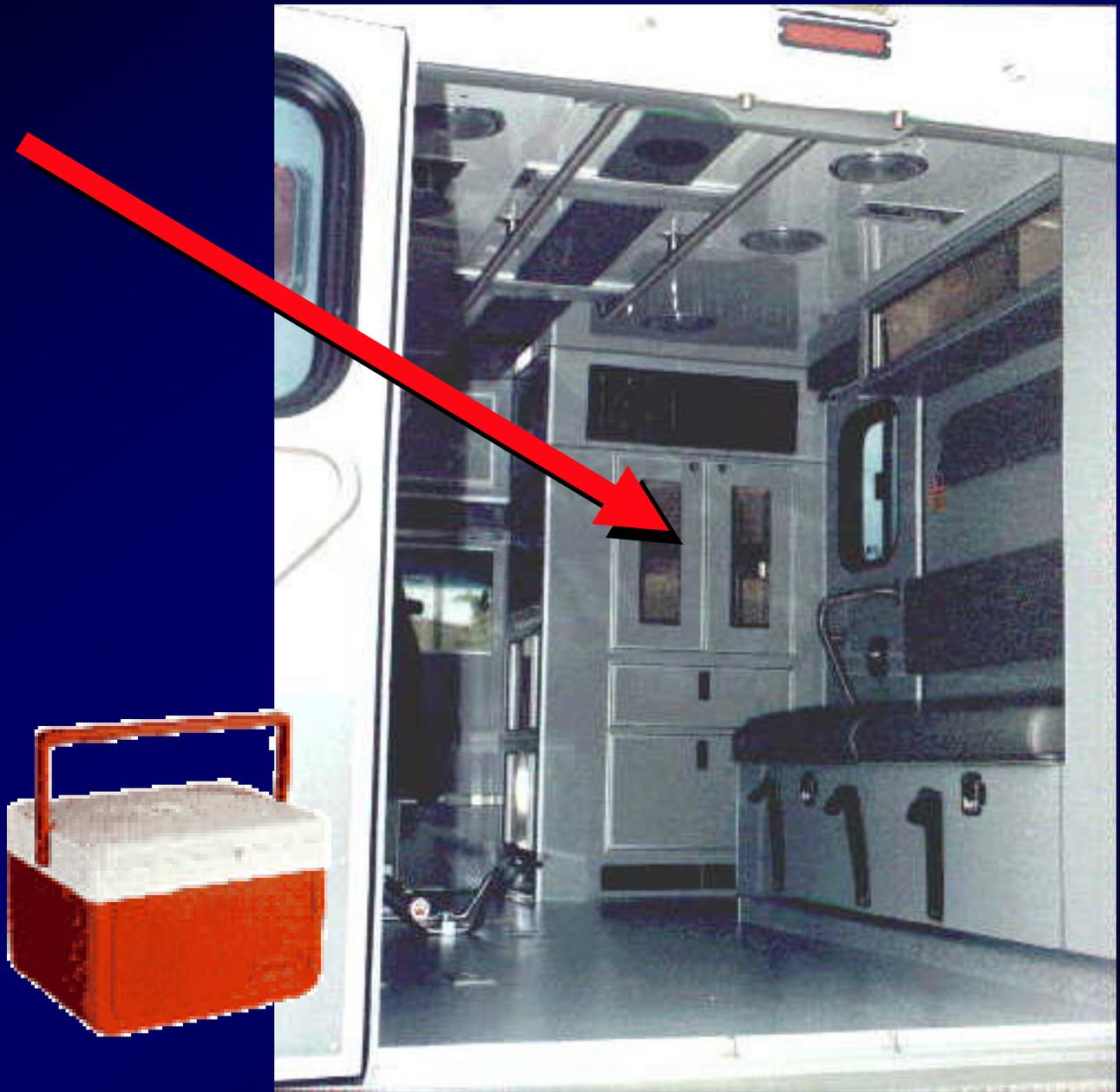
“One person has called”

“It was too big for the unit”

WHAT  
REALLY  
IS  
THE  
FUTURE?!?

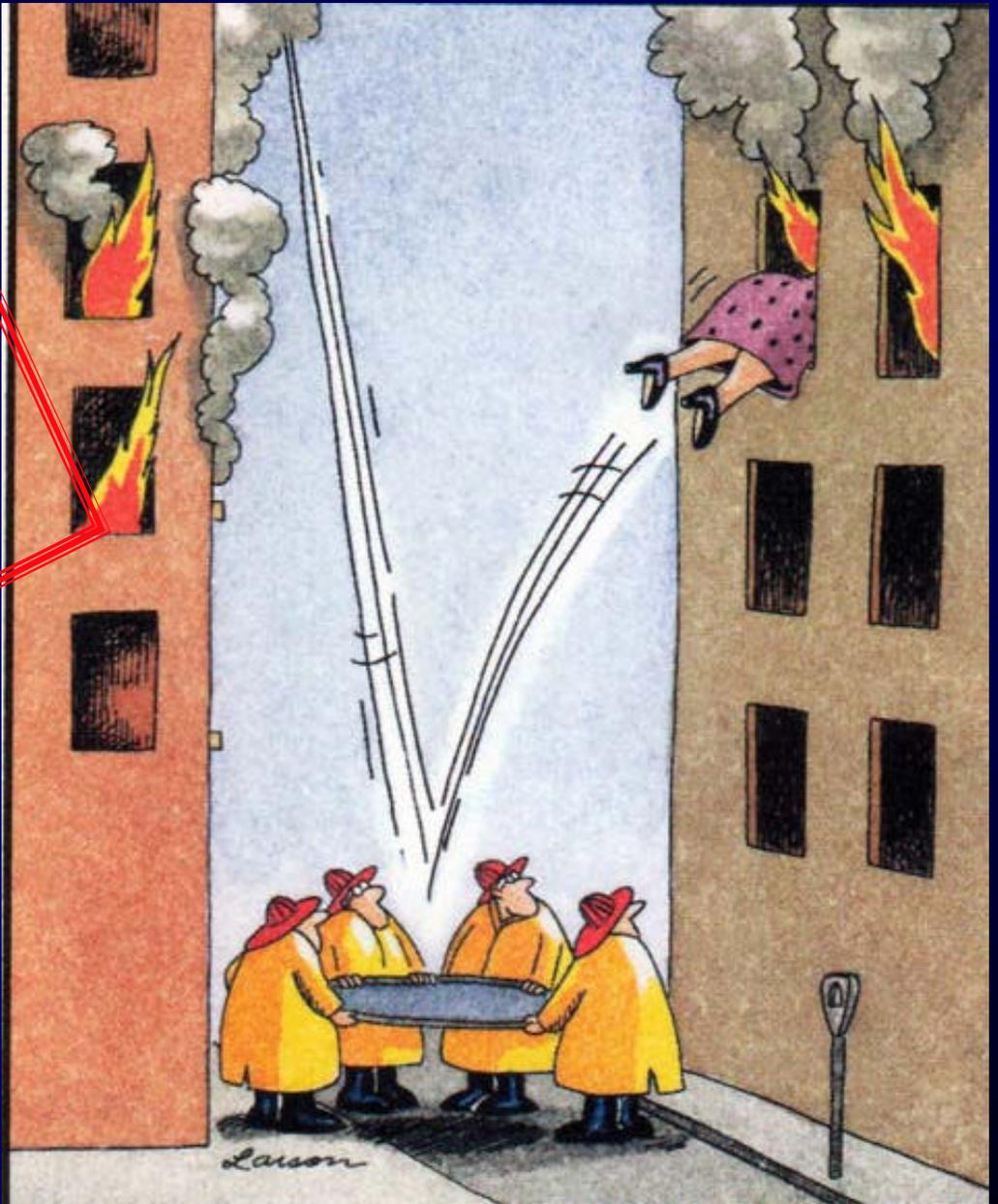








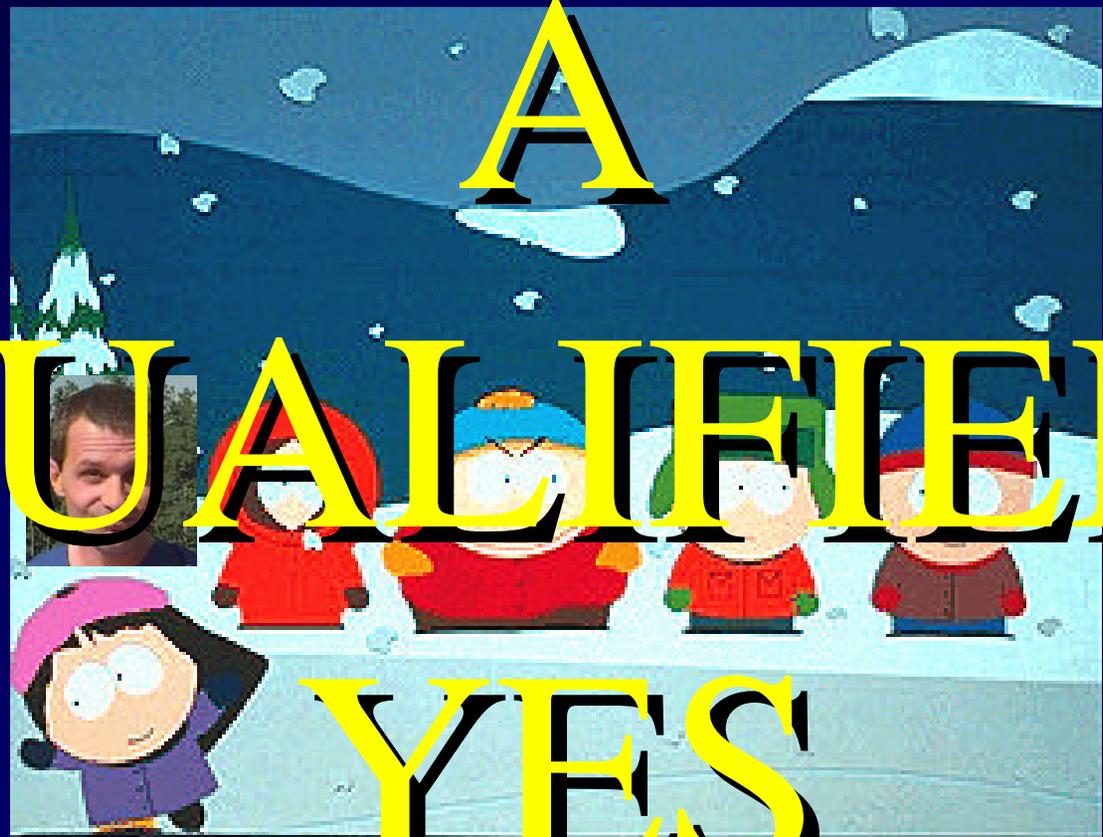
# Synthesis



Can we  
resolve this  
medications  
temperature  
problem??



A  
QUALIFIED  
YES



# Immediate Issues

1. Drug boxes have to be changed out more often if the boxes are not kept refrigerated. How often?
2. Ativan needs to be refrigerated.
3. Little is published about the other drugs
4. Epinephrine is known to break down also, which should mean that Levophed does also
5. Pills in a solid matrix are known to be temperature stable

**ETMC  
EMS**

Proton







BSI Weight	Dosing	Intermittent	ADJUST DOSE	Intermittent	Terminal	Adaptation	Intermittent
40 kg	0.5 mg/kg 10mg - 1.5hr						
50 kg	0.75 mg/kg 15mg - 1.5hr						
60 kg	0.9 mg/kg 18mg - 1.5hr						
70 kg	1.05 mg/kg 21mg - 1.5hr						
80 kg	1.2 mg/kg 24mg - 1.5hr						
90 kg	1.35 mg/kg 27mg - 1.5hr						
100 kg	1.5 mg/kg 30mg - 1.5hr						
110 kg	1.65 mg/kg 33mg - 1.5hr						
120 kg	1.8 mg/kg 36mg - 1.5hr						









“William Moore” <wmoore@etmc.org>

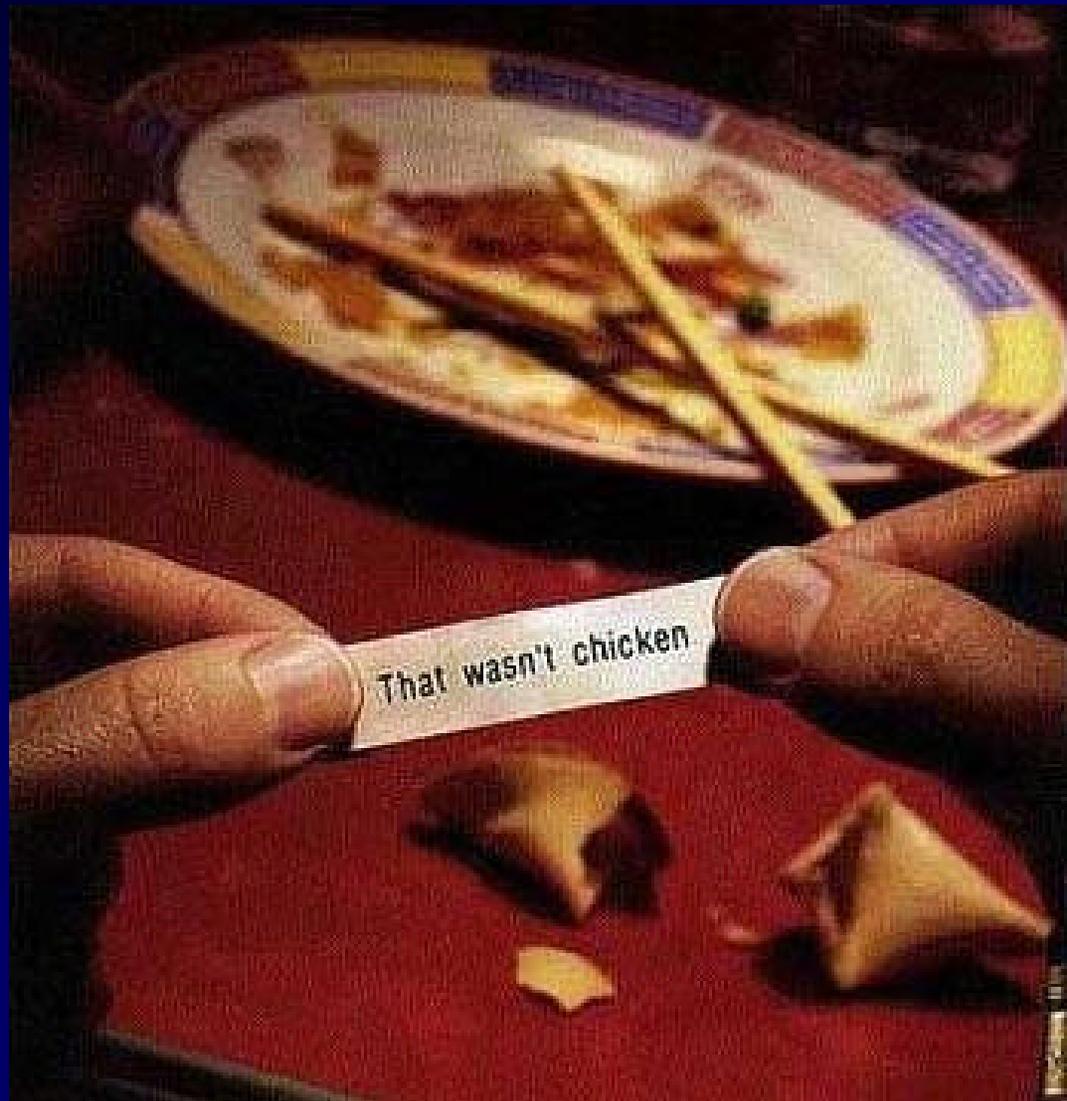


Solution from  
Carrollton, Texas

*Backpack  
Cooler*

*(from Costco,  
I think)*

David Lee <David.Lee@cityofcarrollton.com>



# Future Issues and Dilemmas

1. Future ambulances should be equipped with chambers that maintain temperature.
2. Problem is, the technology is not commonplace at this time
3. Optional temperature control devices are available from ambulance makers, but at what cost?

## Key Features

### P.A.F.<sup>®</sup> System

Exchanges air in the patient compartment every 90 seconds. It also produces a greater volume of air at a lower velocity.

### Printed Circuit Board

With LED self-diagnostics. Eliminates more than 300 wire crimps and connections to minimize failure areas.

### Corner-Cap Lights

Provides 360-degree lighting coverage. Also available with optional strobe package.

### AWV Grille Assembly

Patented design maximizes air flow for cooling systems and protects your speakers and warning lights.

### Radius Corner Cabinetry

Designed to prevent blunt trauma injuries.

### Aluminum Cabinets

Lightweight, customizable, durable design offers rounded corners and a rolled-up, sealed floor system (optional).

### Seamless Doors

New reinforced, smooth operating pan-formed style doors feature non-adhesive extruded gaskets and a precision action automotive style latching system, offering intrusion resistance to all environmental elements (optional).

### CHASSIS:

- Ford E-350 Dual Rear Wheel Cutaway, 138" WB, 10,700# GVWR (158" WB, 14,050# GVWR, Optional)
- 7.3 L Turbo-Diesel (445 CID), Ambulance Prep Package
- 4600# Front Axle, 7800# Rear Axle
- Electronic 4-Speed Automatic Overdrive Wide Ratio Transmission
- Tilt and Cruise
- Intermittent Wipers
- AMFM Electronic Stereo/Cassette with Clock
- High Back Velour Seats with Armrests (XLPkg)
- Power Windows and Door Locks
- Carpet on Cab Floor (XL Pkg)
- 37 Gallon Fuel Tank
- Dual Air Bags

### PREP PACKAGE:

- Dual OEM Alternators
- Throttle Idler
- Dual OEM Batteries, 1500 CCA Total
- 4.10 Limited Slip Axle Ratio
- Auxiliary Transmission Oil Cooler
- 684 Handling Package
- 57L Auxiliary Heater and A/C Package
- Rear Step
- Non-Skid Extruded Sill Added to Rear Bumper
- Paint Design
- (Optional)
- Insulation
- Fiberglass in Walls and Ceiling

### PATENT MODULE:

- Module
- 149" X 95", (163" X 95", 170" X 95", Optional)
- Headroom
- 66" Interior with Crowned Roof to Inhibit Water Pooling (72" Optional)
- Modular Exterior Compartment Configuration
- RF Compartment, A, Inside/Outside Storage with (1) Adjustable Shelf
- RC Compartment, B1, Storage
- RR Compartment, B2, Backboard Storage
- LR compartment, D, Spare

- Tire and Stairchair Storage (Alternate Sizes Available)
- LC Compartment, E, Storage
- LF compartment, F, Oxygen Storage

### Windows

- Curbside Door, Sliding, Tinted
- Rear Doors, Fixed, Tinted
- Rear Bumper
- With Center Flip-Up, Non-Skid Expanded Metal, Under Body Skids with Integral Tow Eyes

### Fender/Fare

- Black Rubber
- Skirt Rails
- Lower, Diamond Plate
- Kickplate
- Diamond Plate with Recessed Tag Area
- Stone Guards
- All Four Corner, Diamond Plate

### Paint Design

- (Optional)
- Insulation
- Fiberglass in Module Walls and Ceiling, Solid Block Foam in Doors

### ELECTRICAL:

- Heat-Air Conditioning/P.A.P.<sup>®</sup> System
- Three Filter Air System
- Fully Automatic with Thermostat in Action Area
- Circuit Breakers
- Auto Resetting, Pole Style on a Printed Circuit Board
- Shoreline
- STD 15 AMP GFI Protected Circuit, Inlet Mounted by Driver's Door, on Face of Module
- (1) Outlet Mounted in A/A
- (1) Outlet Mounted on Curbside Wall, at Foot of Squadbench
- 12 Volt Outlets
- Milspec Style, (2) in A/A

### EMERGENCY LIGHTS:

- Light Bar
- (Optional)
- Flasher
- Dual Mode Solid State
- Grille Lights
- (2) 7" x 3" Halogen, Red Lens
- Intersection Lights
- (2) 7" x 3" Halogen, Red Lens
- Warning Lights
- (8) 9" x 7" Halogen, Red Lens

- (2) Front, (2) Rear, (2) Each Side
- (1) 9" x 7" Halogen, Amber, Center Rear
- (1) 9" x 7" Halogen, Clear, Center Front
- Load Lights
- (2) Optiscene, 9" x 7", 26-Degree Angle on Rear
- Strobe Lights
- (4) Optiscene, 9" x 7", 13-Degree Angle, (2) Each Side
- Tail Lights
- (6) Rectangular Sealed Lights Installed in Rear Diamond Plate Kick Panel
- Siren
- Wholen WS-295HFS Located in Front Switch Console
- Siren Speakers
- Wheeled Coach Grille A/W System with (2) 100 Watt Drivers and (2) Grille Lights
- Back Up Alarm
- Installed Under Rear of Module. Cut-Off Switch (Optional)
- DOT Clearance Lights
- Exclusive Integrated Corner-Cap Lights and (3) Amber Front and (3) Red Rear
- Spotlight
- (1) Handheld, 100,000 CP
- Patient Domes
- (7) Weldon Model 8045 Halogen Lights Mounted in Recessed Headliner, (4) Over Cot, (3) Over S/B
- OXYGEN/VACUUM:
- Oxygen Outlets
- (2) Ohio Style Fitting in A/A
- Vacuum Pump
- Thomas E-12V, Mounted Under Attendant Seat Base

### CABINETS & HARDWARE:

- Radius Corner Wood Cabinets & Seamless Upholstery (Aluminum Cabinets Available)
- Patient Module Liner
- One Piece Fiberglass with Recessed Light Area and Recessed Center Grabrail Area
- Grabrail
- 1" Diameter Handicap Style with Rounded Ends
- Assisted Handle
- (1) Each Entry Door
- L.V. Holders
- (2), (1) Over Cot and (1) Over Squadbench Chest Areas
- Attendant Seat
- High Back Captain Chair on a Wood Cabinet
- Flexiglas Doors
- Sliding Doors with Full Length Aluminum Handles
- Right Front
- Full Height and Width Cabinet Storage with (2) Wood Doors, Inside/Outside Access
- Streetside Basewall
- CPR Side Seat with ABS Trays in A/A and Telemetry Area
- Action Area
- Angled Wood Console with Vinyl Clad Control Panel
- Angle Increases Visibility of Controls Throughout Work Area
- ABS Plastic for Ease of Cleaning
- Squadbench
- Single Lid with One Piece Seamless Cushion and Seamless Backrest
- STAR OF LIFE DECALS:
- (Optional)



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UNITS SHOWN WITH OPTIONAL EQUIPMENT

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# Closing Question??????

Are ambulance services prepared to spend costs approaching \$1,500 per rig to adequately equip EMS units

- **ANY VEHICLE CARRYING MEDS** -  
for temperature control of medications?

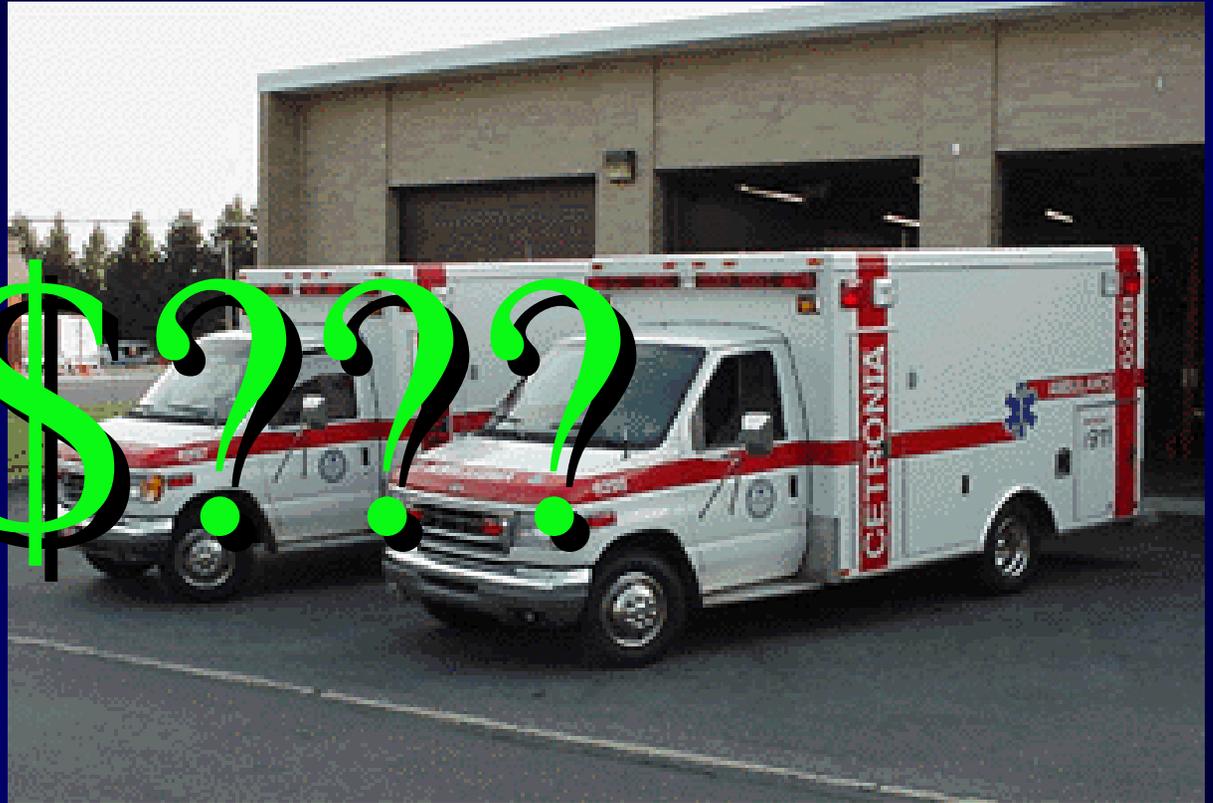
The Texas Department of Health  
has issued a warning  
to all providers of Emergency Medical Services  
that the operators of the vehicles  
will be responsible for the  
proper storage of medications  
and devices, or face possible state action  
against their  
license and operation.







\$\$\$???



*...thank you for your kind attention*

[www.doctorfowler.com](http://www.doctorfowler.com)