I would like to propose a new concept for the safe transportation of refrigerated vaccines:

“**If nothing in the cooler is less than 0° degrees Celsius (C), the vaccine cannot freeze!**”

Although I realize that the best practice is to never transport vaccines once they arrive in your office, physicians occasionally need to move vaccine. Weather emergencies, power failures, equipment failures, and stock redistribution between main and remote offices, can necessitate the need to safely move vaccines.

As vaccine providers, we are all familiar with the concept of Cold Chain handling and storage of vaccines; we know that refrigerated vaccines should be between 2°C and 8°C at all times and we are generally good at keeping the vaccines from becoming warm. The problem is that we try too hard to keep vaccines cold and set ourselves up for the largest risk of potency loss - the risk of silently freezing the vaccine! Damage due to freezing is immediate, whereas damage due to warmth can generally be mitigated based on duration and temperature. One of the most important lessons that experts studying vaccine storage and handling practices have learned is that freezing refrigerated-vaccines -even for a moment- can render them useless. Administering these vaccines can leave children unprotected against diseases.

The freeze risk can be avoided with proper packing of vaccines for transportation. There are a few general principles –

1) Do not transport frozen vaccine (those containing Varivax) in the same container as refrigerated vaccine.

2) Always hand-carry by a trusted & trained employee; never delegate to a commercial service.

3) It is against Food and Drug Administration regulations to transport “open” multi-dose vials of vaccine. All opened vials must be used in the facility that opened them.

4) For long trips, use thick-walled polystyrene coolers like the ones that manufacturers use to ship vaccine. They are sturdy and have interlocking, tightly fitting lids. The CDC recommends using portable refrigerator units, but they are costly and often not available.

5) If polystyrene coolers are not available, consider using a collapsible cooler that can be pre-stored in a refrigerator so that it is already chilled. It can then be placed in a larger hard-sided cooler with additional coolant for longer transportation, if needed. While the CDC recommends hard-sided coolers as a second choice to transport vaccines, hard-sided coolers do not maintain temperature as well as thick-walled polystyrene coolers.

6) Use only conditioned frozen water bottles (CFWBs) as the coolant – do not use frozen gel packs

CFWBs are the key to safe transport. They are clear plastic drinking water bottles you can buy by the case at grocery stores that have been hard frozen and then “conditioned.” “Conditioning” means warming them until the frost on the outside turns to droplets of water and you can see a small amount of water on the inside of the bottle where the solid ice has begun to melt. Once you see ice and liquid water coexisting in a container, you know that the bottle is exactly 0°C and no colder! If CFWBs- by definition - are not below zero, it is impossible to freeze vaccine using conditioned bottles as the only source of “cold!”
Conditioning frozen water bottles is easy – after freezing, leave them out on the counter approximately 20 - 30 minutes, until you see a small amount of liquid water inside the bottle. If you are in a hurry, place the frozen bottles in a sink and cover with water. The bottles are generally conditioned after 3 to 5 minutes of exposure to water. Either way you condition the bottles, double check them as you place them in a cooler with the vaccine to ensure that there is liquid water visible around the ice.

**How to pack the cooler?**

If the cooler is large enough, layer in the following order:

- conditioned frozen water bottles,
- cardboard or table paper,
- the refrigerated vaccine,
- cardboard or table paper,
- and a more conditioned bottles on top.

If the cooler is not big enough for two bottle layers, at least put the layer on top (not the bottom). The cardboard or paper can protect the vaccine from condensation. Specific cooler needs can vary based on the amount of vaccine, duration of transport, and ambient temperature encountered. In the winter, you might need to protect from freezing outside temperatures rather than from heat. It is best not to risk exposing the transport container to freezing conditions externally.

**How to tell if the vaccine arrives at the right temperature?**

Just look at the conditioned bottles! If you still see ice + water, then the bottles are still at 0°C! If the cooler is of sufficient quality, everything inside will be nearly the same temperature and not below 0°C. When I have tested my own shipment coolers with a data logger, the contents were rock-steady at 2°C for over 48 hours. A data logger can be helpful to improve comfort with this technique and/or to verify your practice transports.

**Aren’t gel packs better at keeping things cold?**

In tests I did with 6.5 pounds of hard frozen gel packs in a small Varivax shipping container (8”x8”x9” internal size), stored in a 74°fahrenheit (F)-78°F room, the duration below 8°C was 86 hours. However, it had started off being below 0°C for 8 hours with the lowest temperature achieved being -9°C. These frozen freezer bricks would have silently frozen and destroyed all freeze-sensitive vaccine in the box! Never put vaccine in a cooler with coolant less than 0°C! The same test was repeated with 6.2 lbs of conditioned water bottles. The time below 8°C was 72 hours and the lowest temperature recorded was 2°C – a safe temperature for refrigerated vaccine.
So what makes Conditioned Frozen Water Bottles (CFWB) perfect for safe vaccine transport?

Although frozen gel packs may seem like an obvious choice they are not optimal. The phase change for gel going from a frozen state to unfrozen state is below 0°C; plus, it is not predictable since there are many different formulations of gel packs. A brief high school science class refresher: Two terms to understand as they relate here-

1) Specific heat: The amount of heat required to change the temperature of a specific weight of an object by 1°Kelvin (K).
2) Latent Heat: The amount of heat absorbed by a quantity of substance during the phase shift from ice to water without changing the temperature.

The appearance of water in the frozen water bottle means that both water and ice are existing in the same container at the same time; that means the only temperature the bottle can be is 0°C. Unlike the frozen gel bricks, you can look at a conditioned frozen water bottle and know that the temperature of the bottle is precisely 0°C. The specific heat of ice is half the specific heat of water – this means that the amount of heat required to move ice 16° (say from -20°C to -4°C) is equal to the amount of heat to move water from 0°C to +8°C. Ice is not a very good absorber of heat as “ice.” However, – and this is important – water has an extremely high latent heat value; to move 1 kg of ice at 0°C to 1kg of water at 0°C, it takes almost 80 times the amount of heat required to move the same weight of water 1°C!

Why don’t we just follow the CDC’s Vaccine Storage and Handling Toolkit?

Since the June 2012 OIG report, which found Vaccines for Children (VFC) vaccine exposed to temperatures outside of the recommended ranges, the CDC has provided interim guidance and re-wrote their toolkit. The Toolkit is available on the web at:

http://www.cdc.gov/vaccines/recs/storage/toolkit/default.htm

There are a few suggestions in the Toolkit that may not promote the safest practice:

1) For transportation, it describes packing Varivax and refrigerated vaccine in the same container. This can create an unsafe environment for both types of vaccine! Please use separate containers. (Also, note this article does not address shipping frozen [Varivax containing] vaccine – only refrigerated vaccine.)
2) It suggests the use of conditioned frozen gel coolant packs. As discussed, CFWB’s are more available, predictable, and won’t freeze vaccine!
3) It implies that wrapping vaccine in insulation will protect it from freezing. If the inside of the box goes below 0°C, it may take a few hours, but everything in the box will eventually reach 0°C, regardless of insulating with bubble wrap. It is good to protect the vaccine from the wet condensation on the CFWBs with cardboard or table paper, but protecting the vaccine from freezing is more important.

I suspect the Toolkit will improve with each edition.
So Let’s Get Packing – SAFELY!

Again, it is always best to not transport vaccines. Over the years our three-site general pediatric practice has transported vaccines routinely – we have discontinued that practice. We now have the majority of vaccines needed shipped directly to each office. Occasionally, we have to even out inventory and we are much safer now than in years past! Remember, there is no advantage to using gel packs over CFWBs. Understand when you see water and ice together you are looking at 0°C – not above, not below, but exactly 0°C. Zero does not hurt vaccines – but freezing can leave them impotent!