Chapter 11

Metric Isolation & Its Consequences

The US entered into the current long period of metric isolation after the metric board was extinguished. An intrinsic problem with persuading people to embrace metric, is that it first assumes they already understand the system. Discussions and arguments about the metric system and its usage were completely unknown to citizens of the United States. This isolation caused them to remain ignorant of how persons in other countries were debating and creating new and better ways to use metric, while the US continued to channel the 18th century past for its usage, when metric was used at all.

The metric system, as it was first articulated, was a vast improvement over the endless polytheistic units, which had been inherited from thousands of years of groping in the dark. But when a new concept is embraced, although simpler than what it replaced, further introspection can reveal more efficient and intuitive ways of using it.

Early usage of the metric system apes the manner in which the ancient confusion of units were implemented. To this day, in some countries, one finds drawings which have numbers written in this manner: 1.20.7 Yes, that is not a misprint, they employ two decimal points. The number represents 1 meter 20 centimeters 5 millimeters. Countries which adopted the metric system early on, interpreted the new system with the common usage found with pre-metric units. For instance one might have a height of 5 feet 10 inches 2 barleycorns. The mixing of pre-metric units was common, and only provided a source of increased complexity and opportunity for error where it was unnecessary. Perhaps the most important property a measurement system should have is *simplicity.*

The human mind has an internal model of how it believes the world works, and constructs an abstract set of physics, that is often called *intuitive physics*. The problem with intuitive physics is that it causes people to believe that heavier objects fall faster than lighter ones, that a ball rolling off then end of a table will travel outward for a moment and then drop. It took study and experiments to determine that these obvious "common sense" ideas did not match the physical world. *Intuitive measurement* also fails us, it is why we need to create measurement methods in the first place.

It was taken as an axiom, that the metric system should have a unit which has a magnitude that was similar to an inch. This notion was so entrenched that even titanic minds like Carl Friedrich Gauss (1777-1855) and James Clerk Maxwell thought that the metric unit which made the most sense for a measurement basis was the centimeter. But, the centimeter is an intellectual iceberg from the past.

The problem with using centimeters was articulated during the 1921 Metric System Hearings on Monday, October 31, 1921 (1921-10-31) by S.M Vauclain, President of the Baldwin Locomotive Works of Philadephia PA:

> If we are going to work in the metric system we will think in the metric system, and you have no difficulty. You know how long a meter is, and you can visualize a meter; you can visualize a millimeter. Very few people pay any attention to the centimeter, as the millimeter is so easy to handle. A thousand millimeters is a meter.
>
> Another thing: In our present system, when we are handling small apparatus, which I have been doing a good many years, the unit of 1 inch, which we now use, is not small enough, and we frequently speak of such dimensions as fifty-seven sixty-fourths. I ask you, can you visualize what fifty-seven sixty-fourths is? You can not. Hardly anybody else can. We don't know what those things are, and as a rule engineers who are working with these matters every day use decimals instead of fractions; but we would rather use metric decimals than present decimals. If you wanted to write that in metric dimensions you would write 23 millimeters. You can visualize 23 millimeters. but you can not visualize fifty-seven sixty-fourths, because it is a very unusual dimension.

> We have, for another example, a working drawing presented by a prominent locomotive company in the United States. It is a side and top view of an ordinary gauge cock. The drawing is full size. The words "all dimensions in millimeters" obviate the need for the familiar abbreviation, m. m. after the figures in the drawing. There are 39 dimensions noted, and not one of these includes a fraction of any kind. If inches had been used in the design and manufacture of this particular American product, only 6 of the 39 dimensions could reasonably have been expressed in an integral number of inches.
>
> That is, by doing the work in millimeters the inconvenience of 33 fractional numbers and the corresponding involved calculations were avoided. These two illustrations are typical of the saving effected in the measurement of length, area, volume, and in the more involved calculations. It may fairly be said that the more difficult the problem the greater is the advantage in having it worked out in the metric way.

When Australia, Bangladesh, Botswana, Cameroon, India, Kenya, Mauritius, New Zealand, Pakistan, South Africa, United Kingdom, and Zimbabwe contemplated introducing metric into their construction trade, they chose the millimeter.

The formal recommendations for metric construction in the United States is in the Metric Design Guide (PBS-PQ260) September 1995. Here is what it has to say about the use of centimeters in construction:

> **Centimeters (cm)**
>
> Centimeters are typically not used in U.S. specifications. This is consistent with the recommendations of AIA and the American Society of Testing Materials (ASTM). Centimeters are not used in major codes.
>
> Use of centimeters leads to extensive usage of decimal points and confusion to new readers. Whole millimeters are being used for specification measurements, unless extreme precision is being indicated. A credit card is about 1 mm thick.

Here is the Guides statement about millimeters:

Figure 11.1: The 990 mm to 1070 mm section of a mm only Australian tape measure used in building construction.

> **Millimeters (mm)**
>
> SI specifications have used mm for almost all measurements, even large ones. Use of mm is consistent with dimensions in major codes, such as the National Building Code (Building Officials and Code Administrators International, Inc.) and the National Electric Code (National Fire Protection Association).
>
> Use of mm leads to integers for all building dimensions and nearly all building product dimensions, so use of the decimal point is almost completely eliminated. Even if some large dimensions seem to have many digits there still will usually be fewer pencil or CAD strokes than conventional English Dimensioning

Even though a metric system construction guide, which is in line with international standards, exists, it remains obscure, and makes no impact in the US. The rest of the world discussed metric, some of them changed to the more streamlined method of construction, but in the US, people had no idea this was even an issue. In 1974, Australians changed their housing construction industry to metric in two years. All measurements are in millimeters, meters or Kilometers (no centimeters). It means that Australian builders never need to use fractions when constructing a home, not even decimal points. All dimensions are in whole numbers.

America's metric isolation means that very, very few US citizens have ever seen a metric only millimeter tape measure. A section of one is shown in Figure 11.1

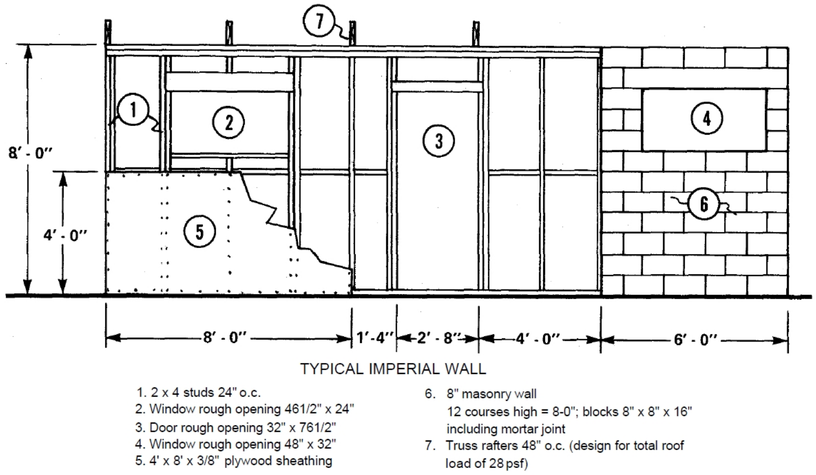


Figure 11.2: Construction drawing in traditional measures in feet and inches.

The Canadian Government created a pamphlet explaining the virtues of metric construction (even though Canada has not switched to metric construction). They have the plans for the wall of a house in both Imperial and metric. The Imperial illustration is in Figure 11.2 The metric illustration, Figure 11.3 is in millimeters.

The dimensions in Figure 11.2 use two different measurement units which have a 1:12 relationship (i.e. feet and inches) and are spelled out separately, so that they must be added and subtracted by converting between them. The inch units also have attached fractions which must be taken into account. The metric version of the same wall is in a single unit, millimeters, with all integer values, save one. The metric plan is streamlined when compared with the Imperial version.

Usage like this, which is common in many metric countries, is met with disbelief and even hostility when presented to US citizens. Generally there is an objection based on thoughtless folklore that "you don't need that much precision" or "those numbers are just too big." The notion of using all millimeters to construct a house is so foreign to American thought that it shocks it. This is because of our international metric isolation.

What has been discovered in metric countries, is that workers will try to cut to within a mm or so if possible. This produces construction

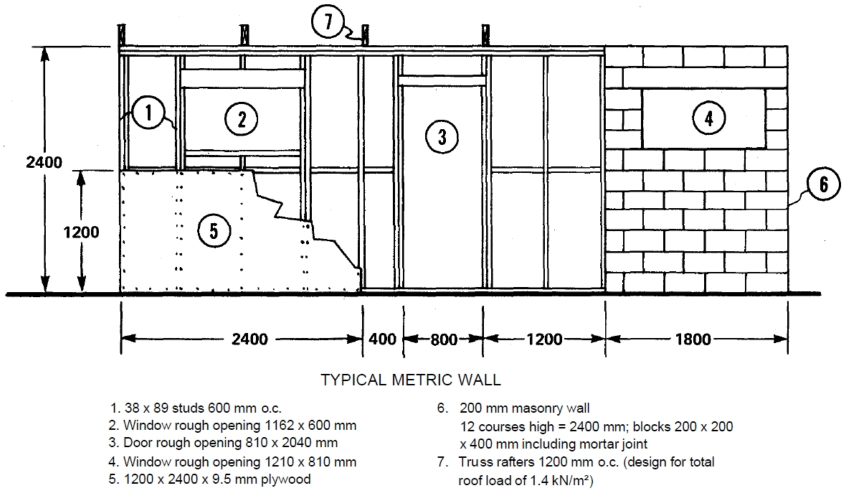


Figure 11.3: Construction drawing in metric with all dimensions in millimeters.

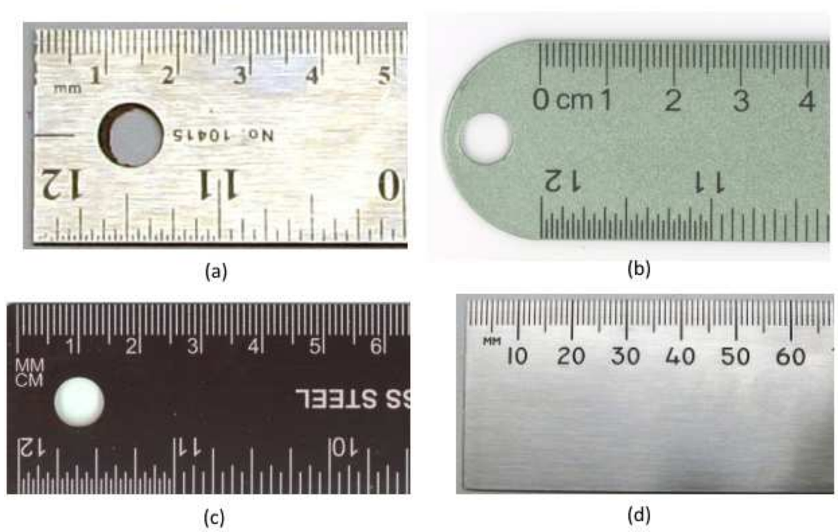


Figure 11.4: Unit designations found on US rulers are generally confusing and incorrect. (a) Centimeter ruler with millimeter graduations is designated as a millimeter only ruler. (b) Centimeter ruler without millimeter or tenth of centimeter designations (c) Centimeter ruler with ambiguous centimeter and millimeter designation using upper case. (d) Millimeter only metric ruler designated as millimeters using upper case.

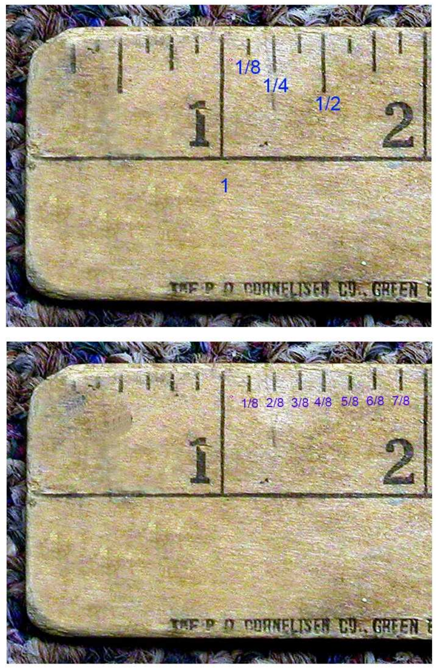


Figure 11.5: The upper image is of a common wooden yardstick with fractional divisions marked for illustration. The lower image reduces these fractions to a single designation.

which is much more precise, and fits together more accurately than non metric construction when compared with the combination of feet and fractional inches.

There are many practices that exist in the United States which act as intellectual barriers. One barrier is the confusion found on the metric side of dual-scale US rulers. The minimal understanding and utilization of metric in the US produces a confusing set of adopted unit designations. In Figure 11.4 we have four examples of ruler labeling in the US.

Image (a) has a metric side of a ruler with millimeters as its designated unit, but the Hindu-Arabic numerals are actually centimeter divisions. The second example, (b), is a ruler with centimeters as its indicated unit, but does not define the graduations between. This leaves it to the user to decide if this is a centimeter ruler with tenth of a centimeter graduations between or millimeter units between. Ruler (c) realizes the ambiguity, but then produces more confusion by offering up two choices of units centimeters or millimeters for the Hindu-Arabic numerals along its length. It adds confusion with its uppercase designations for cm and mm. The final ruler (d) is the only one of the four with only a single measurement unit, which is millimeters. The uppercase designation is confusing, and a lower case mm would be the best choice to avoid any ambiguity.

Rulers in the US use what appears to be a single unit, but the binary subdivisions are represented as fractions. When measuring a length, a common US ruler generally has fractions that are multiples of 1/1, 1/2, 1/4, 1/8 and 1/16. A measurement generally consists of an integer representation of the 1/1 fraction with a concatenated fraction. Should two measurements not have identical denominators, which is a common occurrence, these fractions cannot be directly added until a common denominator is determined. For instance 5 7/8" and 4 1/2" require one to change the 4 1/2" into 4 4/8" before addition or subtraction can occur.

Most every US household possesses a wooden "yardstick." The finest division for a yardstick is generally one eighth of an inch. In Figure 11.5 the upper image of a yardstick has a different length of graduation line depending on what denominator of fraction is represented. The first four are labeled and designate the locations of 1 1/8", 1 1/4", and 1 1/2" respectively. A very simple change would make the ruler easier to read, and use its measured results in computations. The finest graduation on the example yardstick is 1/8". The lower image of Figure 11.5 has identical graduation lengths, (as there is no longer a need to designate different denominators) all marked in fractional eighths. If one measures 1 3/8" and 1 7/8" the common denominator is already present and when added becomes 2 10/8" or 3 2/8". To maintain this simplicity one would need to leave the value as 3 2/8", and not reduce it to 3 1/4" which is no longer on our single scale.

This type of simplification is never implemented, and the idea of reducing "improper" fractions like 2/8 to "proper" fractions like 1/4" is the familiar inviable rule thoughtlessly handed down from generation to generation in the US.

High quality metal rulers in the US have a set of divisions on them that most people in the US never notice. Figure 11.6 illustrates this segregation. The first inch is binarily divided down to thirty-seconds

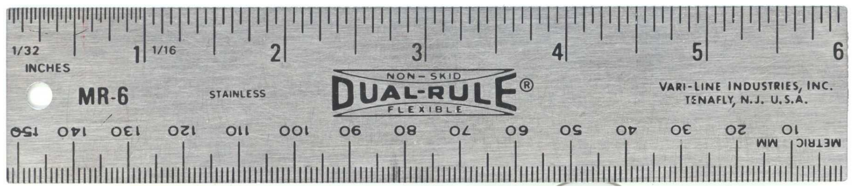


Figure 11.6: US six inch rulers generally have the first inch with fraction lines down to 1/32 of an inch, but then change to 1/16 of an inch for the finest graduations after that. Twelve inch US rulers often have 1/32 graduations on the first and last inch sections.

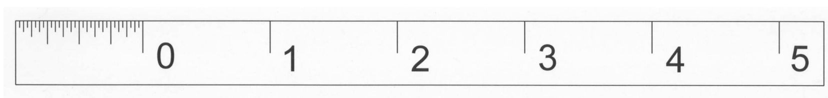


Figure 11.7: Ruler to illustrate the use of the first and last inch of US fractional rulers.

of an inch. Inch 2–6 are binarily divided only down to sixteenths of an inch.

A majority of US citizens never give this separation a moment of thought. If they do, they may assume that the fine divisions on the first inch are there so that when measuring a distance below an inch, one has the option for more resolution. While this is true, it also begs the question as to why the last inch on a foot-long rule is also divided into thirty-seconds of an inch.

Figure 11.7 has a ruler that illustrates how one is expected to use a US ruler for measurement down to 1/32 of an inch. The idea is to line up one edge of whatever you are measuring with an integer inch mark: 0, 1, 2 . . . with the other edge protruding into the region from the edge of the ruler to the zero mark. Suppose one edge of an object is placed on the 4 of the ruler and the opposite edge rests on the 1/4" line in front of the zero. The length of the object would be 4 1/4". The 1/32 designations are there, and so if the value would have been 15/32" in front of the zero, the total length of the object would be 4 15/32".

A US ruler expects you to place the object on 5 so that the other edge is from zero to one, subtract one from five to get four and then add on the amount from zero to one. As one might expect, very, very few people in the US do this or know how to do it. In general, most everyday linear measurements in the US are to 1/16”. US rulers have fractional graduations.

The introduction of decimals took place over two centuries ago, yet US rulers continue to use fractions. Decimals are everywhere in US daily life, ordinary calculators output only decimal values, yet this innovation has not been introduced onto US rulers. An integer (whole) number millimeter ruler has better measurement resolution than a common US ruler. A millimeter is approximately 1/25th of an inch, and many have a second scale with 0.5 mm divisions or 1/50th of an inch. The immediate replacement of US rulers with millimeter only metric rulers instantly increases measurement resolution and decreases numerical complexity.

US rulers are effectively an ongoing experiment that demonstrates when a ruler has dual-scales, the familiar scale will be used over a simpler unfamiliar one. The opposite side of almost all US rulers has a scale that can be interpreted in a decimal fashion, yet almost no one in the US uses it. Australia, New Zealand, UK and other countries that use metric in a streamlined fashion skipped the complicating factor of a decimal point and use millimeter only metric rulers exclusively in their construction industry and elsewhere. None of this underlying theoretical complexity is apparent to the “practical man” in the US, and so he continues to use a fractional ruler, with a nearby fraction to decimal wall chart, for his weekend projects.

The gram is the “millimeter of mass,” and is used in the same way for kitchen recipes in metric, as millimeters are used in construction and engineering. A gram is about the same mass as a plain chocolate m&m or a paper clip. Americans tend to use volume when cooking which is not nearly as repeatable as weighing ingredients. Our international metric isolation also has preserved the use of volume over mass in cooking.

Similarly, the milliliter (mL) is the “millimeter of volume” and has all the advantages of millimeters and grams as no fractions or decimals are needed for everyday use. Liquid ingredients in cooking are measured in milliliters by metric countries.

Here is a simple recipe in metric:

Don’s Soy Sauce Marinade

125 mL LaChoy Soy Sauce
125 mL Orange Juice
30 mL Lemon Juice

12 grams (15 mL) Brown Sugar
30 mL Salad Oil
3 mL Pepper Sauce
1 Clove garlic, crushed
1.25 mL Black Pepper

Combine ingredients. Use to marinate beef, pork, or chicken before grilling or broiling. I usually put it in a Ziploc bag with the marinade for 2 to 4 hours before grilling. . .for a little different flavor add 30 mL of Worcestershire sauce.

Yield 300 mL

The original recipe was in US units and, resided in a cooking recipe computer program which allows one to sort and retrieve recipes. The people who write computer software in the United States are a product of our metric isolation, and will revert to using the metric system in the same way they use the archaic non-system which remains in the US. When the recipe program was asked to convert from US units to metric, one obtained this printout:

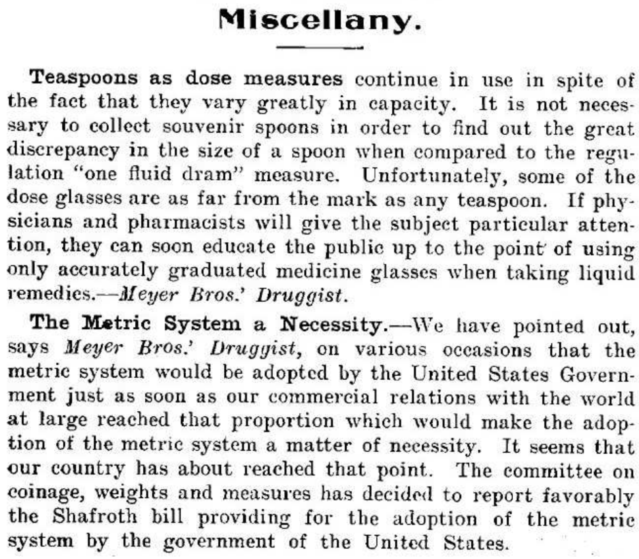
Don's Soy Sauce Marinade

1 1/8 deciliters LaChoy Soy Sauce
1 1/8 deciliters Orange Juice
3 centiliters Lemon Juice
1 1/2 centiliters Brown Sugar
3 centiliters Salad Oil
2 1/2 milliliters Pepper Sauce
1 Clove garlic, crushed
1 1/4 milliliters Black Pepper

Combine ingredients. Use to marinate beef, pork, or chicken before grilling or broiling. I usually put it in a Ziploc bag with the marinade for 2 to 4 hours before grilling. . .for a little different flavor add 30 mL of Worcestershire sauce.

Yield 1 cups

When the metric system is implemented with fractions instead of decimals (which in everyday use most people wouldn't need) and by using atavistic metric prefixes, the recipe makes the metric system not



Miscellany.

Teaspoons as dose measures continue in use in spite of the fact that they vary greatly in capacity. It is not necessary to collect souvenir spoons in order to find out the great discrepancy in the size of a spoon when compared to the regulation "one fluid dram" measure. Unfortunately, some of the dose glasses are as far from the mark as any teaspoon. If physicians and pharmacists will give the subject particular attention, they can soon educate the public up to the point of using only accurately graduated medicine glasses when taking liquid remedies.—*Meyer Bros.' Druggist.*

The Metric System a Necessity.—We have pointed out, says *Meyer Bros.' Druggist,* on various occasions that the metric system would be adopted by the United States Government just as soon as our commercial relations with the world at large reached that proportion which would make the adoption of the metric system a matter of necessity. It seems that our country has about reached that point. The committee on coinage, weights and measures has decided to report favorably the Shafroth bill providing for the adoption of the metric system by the government of the United States.

Figure 11.8: Section from *The Journal of The American Medical Association* September 20th 1902 pointing out the inaccuracies from using common teaspoons and tablespoons. The same section endorses the Shafroth metrication bill of that period.

only appear as complicated as the current set of US units, but perhaps even worse. The manner in which this recipe is converted to metric also illustrates the fetish for grouping multiple unnecessary units.

This practice is taught in US schools, and is ubiquitous in society. The number of inches in a foot, the number of feet in a yard, the number of yards in a mile. The number of pints in a quart, the number of quarts in a pottle, the number of pottles in a gallon. This produces the automatic implementation, and assumption by US programmers, that using deciliters, centiliters, and milliliters is the accepted norm, when only milliliters (mL) would be used to maintain simple whole numbers.

The non-use of milliliters in the US is a serious problem, it can lead to misdosage and death. This problem has been understood at least since the dawn of the twentieth century.

Figure 11.8 has a clipping from *The Journal of The American Medical Association* dated September 20th of 1902.

The article points out that a common flatware spoon has no enforced relationship to a known measure. In the US the two measures associated with a spoon are the teaspoon and tablespoon. These are still used ubiquitously for medicine dosage in the United States. Ordinary flatware spoons are not only uncalibrated volumes, but are generally abbreviated with tsp and tbl. These two abbreviations are often confused. If one confuses tsp for tbl, an administered dosage will be three times more than prescribed, which can lead to an overdose. When tbl is confused with tsp, a dosage is 3 times too low, and can be ineffective. A dosage mistake of this magnitude is more dangerous for a baby or small child than for an adult.

The Journal of The American Medical Association on May 21, 2014 again reported on a group that recommends the US become metric. In one case, a pharmacist mistakenly labeled a medication with a specified dose of 3.5 teaspoons instead of 3.5 mL. In another case, a parent misinterpreted instructions to administer 4 cc (4/5 teaspoon) and gave a child 4.5 teaspoons instead. The cc or cubic centimeter should not be used at all; the milliliter (mL) should be used in its place. In one case a child died because of this confusion.

On November 4th 2015, WVLT in Morristown, Tennessee reported that a nine year old girl had been rushed to the hospital for emergency surgery to remove her tonsils. The surgery was successful, but her father noted something strange on a prescription they had been given. It indicated that she should take 2.5 tablespoons or 12.5 mL. The father, who has a technical background said to WVLT "It didn't seem right that 2.5 tablespoons would equal 12.5 Milliliters [sic]." The article states:

> His daughter was prescribed liquid hydrocodone for her pain. On the bottle they got from Walmart Pharmacy, the label read tablespoons instead of teaspoons, a dosage three times what she was prescribed by her doctor.
>
> "For her, that dosage could have been lethal," says Alexander.
>
> Fortunately, Alexander's background with the metric system paid off and allowed him to catch the mistake before it was too late.

In March of 2016, the American Pharmacists Association voted to support moving away from outdated dosing cups and teaspoons, and instead use milliliters (mL) exclusively. This is only a recommendation, as the APA has no authority to legally compel any company or organization to adopt its ruling. It is another example of voluntary metric in the US, and its consequences. Recent statistics indicate that over 70 000 emergency department (ED) visits result from unintentional medication overdoses among children under the age of 18 in the US.

The confusion of teaspoons and tablespoons continues in the US endangering our health. This is one of the consequences of the lack of mandatory metrication in the United States.[1]

Metric prefixes which were developed early in the history of the metric system, and in retrospect, the prefix cluster around unity, complicates without any added utility. The prefixes hecto, deca, deka, deci and centi are the prefix cluster around unity. A powerful aspect of arabic numerals is they can express large numbers with ease. When paired with prefixes that are spaced by a factor of 1000, the metric system becomes simplicity itself. This has been noted by countries which have embraced metric more recently, than those that did so in the 19th century. The old pantheon of metric units continue to hold more favor in countries that adopted the metric system before the last half of the 20th century.

Because of their metric isolation, Americans have no idea that any debates about the most intuitive and simple ways to use the metric system have ever taken place. They also don't realize how much the current set of US units costs their country because of these inefficiencies, which in turn create waste and cost lives.

[1]The use of MG for milligrams and MCG for micrograms in the United States for drug labeling is another source of dosage error. Incorrectly using MG for MCG, or MCG for MG can cause a 1000 fold error. The proper use of mg and μg reduces this possibility considerably as the two abbreviations are quite different symbolically. The lack of integer (whole number) metric usage by prescribing .5 mL rather than 500 μL is one source of this problem. If a decimal point must be used, then a leading zero, 0.5 mL will help to reduce potential confusion.

