METRIC SYSTEM CONVERSION FOR HOSPITAL DIETARY DEPARTMENTS

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INTRODUCTION

The metric system is rapidly becoming the standard system of measures for the whole world, with 90% of the countries already adopting the system. England, from whom the United States inherited its system of weights and measures, is more than halfway through its ten-year conversion program (1).

The United States is moving toward the adoption of the metric system as the standard, and the switch is inevitable. Although no actual date has been set for conversion, the Senate has approved legislation for the changeover in a ten-year transition period (2). The legislation evolved from the recommendation by former Secretary of Commerce Maurice Stans that was based on a comprehensive three year feasibility study by the National Bureau of Standards completed on July, 1971, with a report entitled " A Metric America- A Decision Whose Time Has Come." The study recommended that the United States change to the international metric system through a systematic nationally coordinated ten-year conversion program with individual segments of society working out their own specific timetable and program (3).

Hospital dietary departments should start to consider the problems of conversion and make appropriate plans to accomplish the changeover with minimum cost and confusion. The longer the decision is delayed, the more the eventual cost of the change will be.

In a statement submitted by the American Dietetic Association as testimony for the United States Metric Study Interim Report, the existence of a confused mixture of customary and metric units was reported, although changes are being made in certain areas. The adoption of the metric system with a definite plan for a ten-year conversion period was favored by the American Dietetic Association (4).

The objective of this report was to provide background information for the changeover to the metric system by hospital dietary departments, and the development of training aids for food service employees.

REVIEW OF LITERATURE

Development of the Metric System

It is natural for one to compare himself with the world around him to get an idea of size. Therefore, the earliest units of measurement represented various dimensions of the human body. The units were rather crude and indefinite. The yard was fabled to have been the distance between English King Edgar's outstretched hands and his nose. The foot was approximately the length of the human foot (5). People obviously vary in size and it was necessary, therefore, to have a more universally recognized measurement system than one based on a man's own body (6). Attention was given to finding a natural object that could be utilized as a standard, one that would be definite and convenient (7).

A system that is wholly rational, simple, and consistent known as the Metric System originated in 1790 when the French began studies to develop an improved system of weights and measures. This system, which has been adopted subsequently by most countries of the world (8), was the first scientific system that correlated weight and volume with a linear unit in a manner other than by chance. The key unit was the meter, defined as a specific fraction of the earth's circumference, and all other units were derived from it (5). Later calculations indicated that the adopted standard (one ten-millionth part of the distance between the equator and the North Pole measured along a meridian) was inaccurate by an extremely small amount. By a more recent definition, the meter is a multiple of the wavelength of the orange-red light in Krypton-86 (9).

The U. S. Customary System is part of the inheritance from days when the thirteen colonies were under British rule. It started as a mixture of Anglo-Saxon, Roman, and Norman-French weights and measures (5). The lack of uniformity in the Customary System has been manifest from the earliest history of the United States. In 1790, President Washington made a recommendation of uniformity in his message to the first U. S. Congress, resulting in a report issued by Thomas Jefferson, Secretary of State. But due to politics and inertia, the proposals were never acted upon. John Quincy Adams made an additional exhaustive report on the adoption of the metric system in 1821. However, he did not believe that the time was right for adoption as most of the United States' trading was with inch-pound England (5). The metric system was legally adopted by the Congress in 1866, but its use was not mandatory. In 1875, the United States was a party to the Treaty of the Meter and became officially a member of the international community endorsing the system (2). For the following decades, while countries all over the world changed to the metric system, conversion in the United States remained a much debated issue. Not until the launch by the Soviet Union of the Sputnik satellite in 1957 when metric units were necessary for high precision work in science and technology; and Great Britain's decision to adopt the system in 1965 did the United States begin serious consideration of the metric system (5). In 1968, Congress took the first step toward a compulsory changeover when it directed the Secretary of Commerce to authorize a three year study to (a) determine current conditions, (b) assess the impact on the United States of world use of the system, (c) consider the advantages and disadvantages of conversion, (d) estimate costs, (e) evaluate alternatives and, (f) make final recommendations based on findings (10). On August 18, 1972, the Senate, by unanimous voice vote, passed the metric conversion act that would make metric measures mandatory within the Federal government in ten years and encourage voluntary conversion throughout the country (11).

The metric act was approved by the House Science Subcommittee on September 20, 1973 (12). The projected date of the changeover to the metric system would be 1983 (13).

Although the processes of legislation may appear to be slow, conversion to the metric system now seems inevitable (2). The metric system already has infiltrated much of American life, becoming more and more familiar to Americans (11). Many groups already work with metric measures and terms in scientific research, testing laboratories, hospitals, clinics, pharmaceutical industry, photography, sports, army weaponry, athletics, autos, and many other manufacturing industries (10, 11).

Basic Fundamentals of the Metric System

The metric system has units for the measurement of length, volume, and mass. The three main units- meter, liter, and gram- can be changed by means of a consistent system of prefixes to more conveniently sized units for specific purposes. These standard prefixes are added to give names for quantities of a particular unit that differ by multiples of ten (5, 14):

tera	10^{12}	pico	10^{-12}
giga	10^{9}	nano	10^{-9}
mega	10^{6}	micro	10^{-6}

kilo	10^{3}	milli	10^{-3}
hecto	10^{2}	centi	10^{-2}
deka	10^{1}	deci	10^{-1}

The International System of Units (SI), a modernized version of the metric system, was adopted in 1960 by the International General Conference on Weights and Measures to achieve a simplified and coherent system of units for uniform international use. It is simplified in that each of the basic units measures a specific basic quantity. Each additional quantity is measured in a unit which is derived by the use of two or more basic units (5).

The six basic units are:

length- meter	electric current- ampere
mass- gram	temperature- Kelvin or Celsius
time- second	luminous intensity- candela

The system is based on the decimal system where multiples or submultiples of any given unit are always related by powers of ten. This greatly simplifies the task of converting larger to smaller measurements.

The basic units of measurements are the following:

Length. The common metric units of length are the millimeter for small dimensions, the centimeter for practical use, the meter for dimensions of larger objects and short distances, and the kilometer for longer distances.

Area. Small areas are measured in square centimeters.

Volume. The most convenient unit is the liter, which is 1000 cubic centimeters or 1000 milliliters. The liter is slightly larger than the U. S. liquid quart but smaller than the U. S. dry quart.

Mass. The gram is the most convenient unit for scientific work, while the milligram is used to express small quantities and the kilogram, larger quantities. In the metric system, mass and volume are correlated, a milliliter of water at 4°C has a mass of one gram.

Temperature. The Celsius or Centigrade scale is used. Pure water at standard atmospheric pressure freezes at 0° and boils at 100°. Normal human body temperature is 37° and a comfortable room temperature is 22° (15).

Comparison with the U. S. Customary System

Definition of Units

One of the first differences one finds when comparing the metric system with the customary system of weights and measures is in the definition of the units. The meter is defined as a part of a natural unit, its standard. It is scientific and invariable, always reproducible from natural phenomena (7). All other units of the metric system have been derived and could be reestablished from this one unit. On the other hand, this would be practically impossible with the U. S. Customary System, which has come from primitive times, developed in an unregulated manner (14), with no logical pattern to it (5).

Relationship between Consecutive Units

The metric system has decimal divisions of its units. All of its units are divided into tenths (16), which makes for easier learning and computation. In many operations, the decimal point needs simply to be moved from one position to another (7). This is not so for the customary system. Computations are much more laborious and require not only memorizing arbitrary and various conversion factors but also using long number multiplication and division with resulting fractions and mixed numbers. Conversion formulas are not even constant; for instance, there are 2240 pounds to a long ton but only 2000 pounds to a short ton (17). The number 10 and its multiples are much easier to manipulate than a series of seemingly unrelated numbers, for example:

137 cm = 13.7 dm = 1.37 m

137 in. = 11-5/12 ft. = 3-29/36 yd.

Terminology

The metric system has a systematic nomenclature. When the vast number of confusing units and terms with which we have to be familiar in the customary system are compared to three simple terms- meter, liter, and gram, which constitutes the metric system-, the advantage is at once evident (16). There are many units of length and area in the customary system. Units of volume are not related to units of length and there are two different series for liquid and dry measures. Two different sets of mass units are in use, the avoirdupois and troy or apothecary. The same names are used for different units; for instance, there are four ounces, two tons, two miles, three quarts, or two gallons. There are 56 kinds of bushels, which also vary from state to state and according to commodity (18).

Interrelationship between Units

The basic units in the metric system are related to each other. The units of length, capacity, and weight are interrelated and readily determined in terms of one or another. A unit of volume has unit dimensions and a corresponding unit of weight as illustrated by the fact that a cubic centimeter of water weighs exactly one gram (16). The customary system has no such relationship. It consists of separate, unrelated systems for weight, volume, and length; for example, one cubic foot of water weighs 62.4 pounds (18).

The customary system is not without its merits. It is closely related to everyday human experience and human anatomy, from which units were derived in the past. The multiplicity of units actually is a convenience for those who use them. Numbers between 1 to 1000, as when one buys a few pounds of potatoes, are easily figured. The number 12 is a handy base in calculations. It is small and has twice the number of factors- 2, 3, 4, 6 - as the number 10- 2, 5 - has (5).

Converting to the metric system would involve expenses for physical changes in objects, retraining personnel, and redesigning equipment. It also involves intangibles, as the inch system is ingrained in everybody, and it may be difficult to adjust psychologically and " think metric " (5).

The cost of the changeover will, however, be a wise investment toward unification with the rest of the world. It will enable more speedy assimmilation of scientific facts and shorten the lag time between the discovery and application of facts (18).

Considerations in Conversion

Changes

Two kinds of changes may take place in the conversion from the customary to the metric system.

A software change is simply an exchange of one measurement language for another. Its solutions involve paperwork and training of people, as in the retabulation of data and learning to think and work in terms of a different measurement (19).

A hardware change involves the altering of sizes, weights, and other dimensions of existing physical entities, as in the modification of machinery necessary when milk is sold by the liter (5).

Purchasing

Current restrictions require that the customary system be used in markets for all foods, with metric units being optional supplementary information (20). Under the current labeling regulations, confusion exists between weight and volume when the term ounce is used, as the qualifying terms may be avoirdupois or fluid. The allowance of subunits as common or decimal fractions adds to the confusion (20). Processed foods are packaged in such a wide variety of sizes that they make quick price comparisons difficult. For all foods sold in packaged form, the Food and Drug Administration requires statements of weights to be in terms of avoirdupois pounds and ounces, statements of liquid measures in gallons, quarts, pints, and fluid ounces and statements of dry measures in bushels, pecks, dry quarts, and dry pints. There seems to be no consistent measurement base on which to make meaningful price comparisons (21).

A planned program of metrication would be of benefit and aid in eliminating the present ambiguity. The different terminology for metric units designating mass and volume together with the ease of computation in decimal units should facilitate food purchasing. It would also eliminate the varied subunits as 16 avoirdupois ounces per pound and 32 fluid ounces per quart. There no longer would be the need to read labels containing mixed numbers. All markings would be consistent and costs per unit would be easily compared (22). Weight in grams makes it easier to compare prices per unit for different sizes rather than when weight is given in a combination of pounds and ounces (23).

The number of language, unit, and size changes would be relatively minor. The principal language and unit change would be from pound and ounce to kilogram and gram. There will be no change in sizes if the change were to metric equivalents. For instance, 1 pound of ground beef would be equal to 454 grams or .45 kilogram. There would be minor changes in sizes if the conversions were to units of easily calculated multiples of grams and decimal fractions of the kilogram. Such variation in size would be quite insignificant, if the units developed were close to actual metric equivalents of customary units and were uniformly adopted (21).

The problem of size difference would exist especially in relation to base units for pricing. For items sold by count or individual unit, the changeover would not have much effect unless it became necessary for all items to be sold by weight (21).

The relearning process would not be limited to speaking and thinking in terms of grams, kilograms, liters, but also to the need to base purchase decisions on the new language units. The simple procedures of dual labeling and the use of conversion charts over a short period of time would help in the educational process (20). Amount-to-buy charts in cookbooks could also be converted easily to metric language and units (21).

Food Preparation

The metric system or a combination of the metric system with the customary system already is used extensively in food and nutrition research, dietetics, food composition tables and science publications.

It is difficult to perform the necessary computations with fractions and mixed numbers using the current system when we need to increase or decrease the yield of a recipe. There is some concern that a changeover would require discarding old recipes and cookbooks and make the expensive replacement of measuring and cooking devices and utentils necessary (24).

Use of food information and recipes from other countries is limited because measuring equipment calibrated in metric units is lacking. The changeover enables simple computations of dietary information and recipes, as quantities are stated in multiples of ten. International exchange and the use of food preparation information would be facilitated (24).

The following food preparation measurements would be converted from the customary system to the metric system:

1. Temperature- A change from the present Fahrenheit scale to Celsius entails no particular difficulty. The freezing and boiling points of water are 32 and 212 for Fahrenheit and 0 and 100 for Celsius. Calibrations would need to be changed on oven controls, freezers, refrigerators, and other electric equipments. Centigrade thermometers for cooking are also available. Through the use of a conversion table, no difficulty would be fore-

seen in the conversion (24).

2. Mass- Weight measures in institution recipes could readily be changed to the metric system, 1/2 kilogram (500 grams or a metric pound) would give a measure 10.2% greater than the English avoirdupois pound (453.6 grams). Scales and balances would have to be replaced or recalibrated. Adhesive tapes showing figures of weights in the new terms masking original digits will be sufficient before replacement (2).

3. Capacity- The capacity of one cup measure for both liquid and dry ingredients in the customary system is established at 8 fluid ounces or 236.6 milliliters; for one tablespoon, 14.79 milliliters; and for one teaspoon, 4.93 milliliters. The liter has a volume 5.7% greater than the quart. To make the change easier, Schlessinger and Kennedy (25) suggested adding two units to the metric system- the metric pint (500 milliliters) and the metric cup (250 milliliters). Fractions of a cup could be expressed as tenths (25 ml = 0.1 metric cup) or as 1/2, 1/3, 1/4 - 125, 83.3, 62.5 milliliters. Cups for liquid measures could be calibrated in either fractions or in tenths of a cup on one side and in milliliters on the other side in place of fluid ounces. Graduations of 10 or 25 ml are suggested for the 250 ml cup. The metric cup is suggested to differentiate 250 ml from 236.6 ml customary cups (Fig. 1) (24).

There is the problem of obtaining conveniently rounded values without changing the relationship

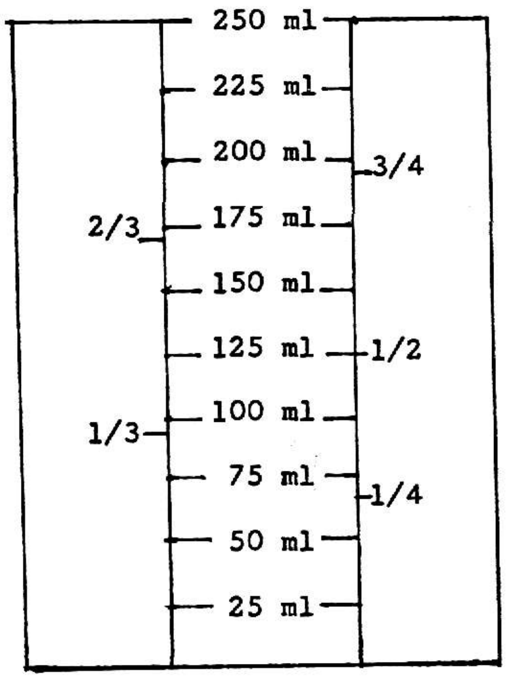


Figure 1. Suggested graduations for a 250 ml measuring device (24).

between basic proportions of measuring devices such as between the cup, tablespoon, and teaspoon. If these relationships could be retained in a change to the metric system, old recipes could be used with the new metric measures with no adverse effects to the product. The yield would simply be increased slightly if the cup size is increased to 250 ml, tablespoon to 15.6 ml and teaspoon to 5.2 ml. On the other hand, customary measuring devices could be used with the recipes in the metric system and turn out a yield slightly smaller (24). Hunt and Green (24) suggested the retaining of the present tablespoon and teaspoon with the change of the tablespoon to 15 ml and the teaspoon to 5 ml. However, Schlessinger and Kennedy (25) stated that a 15 ml tablespoon is not suitable with a metric cup of 250 ml because 250 does not give whole numbers when it is divided by 15; therefore, a tablespoon measuring 10 ml (25 tablespoons/metric cup) or 12.5 ml (20 tablespoons/ metric cup) might be adopted. A tablespoon measuring 12.5 ml seems most desirable except that it is not divisible into a whole number of teaspoons.

4. Length- When the metric system is adopted and if capacities of measuring equipment are conveniently rounded, an accompanying adjustment must be considered for utensil size to accompany the changed yield from recipes. Effects of changes in volume and shape of pans on the cooking time and quality of the finished product must

also be considered. Pan dimensions and other measures of length would be expressed in centimeters instead of inches. A pan 8 x 8 x 2 inches is equal to 20.3 x 20.3 x 5.1 centimeters, with a volume of 2098 cubic centimeter. To eliminate fractions, it could be adjusted to 20 x 20 x 5 centimeters with a volume of 2000 cubic centimeters. The adjustment would result in a 4.7% decrease in pan volume (25). Table 1 depicts some of the possibilities for common pan sizes in rounded metric units (26).

Recipes need to be adjusted to metric dimensions of utensils and be rewritten where straight conversions would upset the balance of ingredients (27). Dual statements of the quantity of ingredients giving both volume and weight in metric units is desirable in new recipes (24).

Equipment

A widespread misconception of those who opposed the changeover was that all hardware would have to be scrapped. This is not necessary, but in the ten-year transition period large amounts of old equipment would have to be scrapped and could be replaced with the new metric (28). Items could be converted on an attrition basis (29). Most would need to be replaced only when they needed replacement due to wear or obsolescence. The cost would not be prohibitive as many would be replaced in any case.

Mass confusion is not foreseen as equipment is not acquired often, and once it has been purchased, one is not concerned with such measurements. However, when the question of replacement of

Table 1. Utensils: Standard sizes in customary, equivalent, and rounded metric units (26).

Utensils	Customary (in.)	Equivalent Metric (cm)	Rounded Metric (cm)
Cake pans:			
Oblong	10 x 6 x 1-1/2	25.4 x 15.2 x 3.8	25 x 15 x 4
	11 x 7 x 1-1/2	27.9 x 17.8 x 3.8	28 x 18 x 4
	12 x 7-1/2 x 2	30.5 x 8.3 x 5.1	30 x 8 x 5
	13 x 9 x 2	33 x 22.9 x 5.1	33 x 23 x 5
Round	8 x 1-1/2	20.3 x 3.8	20 x 4
	9 x 1-1/2	22.9 x 3.8	23 x 4
	10 x 1-1/2	25.4 x 3.8	25 x 4
Square	8 x 8 x 2	20.3 x 20.3 x 5.1	21 x 21 x 5
	9 x 9 x 2	22.9 x 22.9 x 5.1	23 x 23 x 5
	10 x 10 x 2	25.4 x 25.4 x 5.1	25 x 25 x 5
Tube	9 x 3-1/2	22.9 x 8.9	23 x 9
	10 x 4	25.4 x10.2	25 x 10
Pie pans or plates:			
	4-1/4 x 4-1/4	10.8 x 3.2	11 x 3
	5 x 1	12.7 x 2.5	13 x 3
	6 x 1	15.2 x 2.5	15 x 3
	7-1/2 x 1-1/4	19 x 3.2	19 x 3
	9-1/4 x 1-1/4	24.1 x 3.2	24 x 3
	10 x 1-1/2	25.4 x 3.8	25 x 4
	10-1/2 x 1-1/2	26.7 x 3.8	27 x 4
	11 x 1-1/2	27.9 x 3.8	28 x 4
	12 x 1-1/2	30.5 x 3.8	30 x 4

Table 1. Concluded

Utensils	Customary (in.)	Equivalent Metric (cm)	Rounded Metric (cm)
Cookie sheets:			
	10 x 8	25.4 x 20.3	25 x 21
	14 x 10	35.6 x 25.4	36 x 25
	15-1/2 x 12	39.4 x 30.5	39 x 30
	16 x 11	40.6 x 27.9	41 x 28
	17 x 14	43.2 x 35.6	43 x 36
	18 x 12	45.7 x 30.5	46 x 30
Jelly roll pan:			
	15-1/2 x 10-1/2 x 1	39.4 x 26.9 x 2.5	39 x 27 x 3
Loaf pan:			
	7-1/2 x 3-3/4 x 2-1/4	19 x 9.5 x 5.7	19 x 10 x 6
	8-1/2 x 4-1/2 x 2-1/2	21.6 x 11.4 x 6.3	22 x 11 x 6
	9-1/2 x 5 x 3	24.1 x 12.7 x 7.6	24 x 13 x 8
	11 x 7 x 3	27.9 x 17.8 x 7.6	28 x 18 x 8
	16 x 4 x 4	40.6 x 10.2 x 10.2	41 x 10 x 10
Muffin or cupcake:	1-3/4 x 1	4.4 x 2.5	5 x 2
	2-1/2 x 1-1/4	6.3 x 3.2	6 x 3
	3 x 1-1/2	7.6 x 3.8	8 x 4

existing equipment arises, especially if it pertains to built in equipment, one may run into more problems (30), as their sizes will be more critical. Thus, the building and appliance industries need to coordinate their work in this matter (23).

The Joule as the Fundamental Unit in Nutrition

Since the emergence of nutrition as a separate branch of science, the calorie or kilocalorie has been used as the unit of energy. However, calories are not counted in the metric system (31). The joule is virtually unknown to nutritionists, dietitians, and laymen who are well indoctrinated with expressing the energy of foods in calories (31, 32).

The joule is the metric unit of energy defined as the work done in moving one kilogram of mass through one meter of space in one second of time. A food's energy value in joules can be approximated by multiplying the calorie value by 4.18 (31). The calorie is a measure of thermal energy and cannot be derived directly from the basic International System units without using an experimentally determined factor (33), while the joule is an energy measurement defined in terms of the basic units of mass, length and time. This definition has the disadvantage of complicating the calculations of food requirements, even though the changeover implies nothing more than the multiplication of the number of calories by the factor of 4.18. An added disadvantage is the loss of a familiar term which over the years has become a by-word to physicians, patients, food manufacturers, dietitians and the news media (33).

The American Dietetic Association noted that the changeover may have traumatic overtones, both to professionals and laymen (31).

It is always disconcerting to have generally accepted terminology displaced. There is the necessity to relearn, which is a harder process than learning initially because it involves not only acquiring new concepts but also discarding some comfortable ones. Usually, however, the problem involved appears greater in anticipation than it really is (34).

Of major interest is the expression of the energy content of foods. The generally accepted figures of 4 kcal/g for carbohydrates and protein and 9 kcal/g for fat are really rough estimates. When they are changed to kilojoules and rounded off, we have 17 kilojoules/g for carbohydrates and protein and 38 kilojoules/g for fat (34).

The Committee on Dietary Allowances of the U. S. Food and Nutrition Board of the National Research Council has discussed problems and proposes in the next revision of the Recommended Daily Allowances, to include energy allowances expressed in both kilocalories and kilojoules (34).

The adoption of the joule will be delayed by a number of factors. Thermochemical and calorimetric data are not tabulated in joules, and the figures commonly used in nutrition work for estimating the specific energy of foods or the heat produced by animals and man are also expressed in calories. Another important factor will be the conservatism on the part of those who have close concern with the lay public (35).

If the joule is to be given preference, it must be made acceptable and understandable to the nutritionist and dietitian. Otherwise, Moore (36) stated that the price of change is too high. Moore (31) also stated that the joule refers mainly to mechanical work, whereas in biology, the expenditure of energy occurs mainly in the form of heat. He proposed a compromise which is a more realistic and less drastic change. He suggested the redefinition of the calorie as a unit of food, rather than of heat. On this basis, the new calorie could be conveniently defined as " that amount of any food, which, when used in the animal body exclusively for the generation of energy, produces 4180 joules (31)."

Vickers (37) summarized the general feeling toward conversion to the joule in the following words:

> " Although in general the only energy unit to be used will be the joule, the calorie as used internationally in dietetics might well be continued, since its use in that field does not impinge to any serious extent on other fields. Within the confines of this particular application, a change to the joule would involve an upheaval to no very constructive purpose."

Process of Conversion

The process of conversion may be instantaneous or gradual (2). Plans are made months ahead in an instantaneous conversion. Complete conversion is done in one day when all metric equipment and forms will be introduced. This avoids most of the problems found in a staged or gradual transition program, such as the simultaneous use of different equipment and general confusion resulting from the use of both systems (2).

The changeover to the metric system should preferably be organized so that the entire food industry makes the change at the same time, resulting in a minimum of inconvenience and expense to both suppliers and manufacturers. The actual expenses incurred in food service will be minor when compared with other industries where considerable retooling and redesigning of equipment may be involved (3).

Metric System Training Program

In 1970, the Institute for Social Research at the University of Michigan conducted personal interviews with 1400 family units and through the survey, discovered that Americans actually know little about metric weights and measures. About 40% of those interviewed could name some of the metric terms. Less than 20% understood the relationships either within the system itself or between metric and U. S. customary measurements (10). The findings indicated widespread satisfaction with the present system and opposition to conversion. Resistance probably was due to ignorance since the vast majority of those well informed strongly favored adoption (10).

The main problem thus associated with the changeover involves education (3). The greatest problem is not in the metric system itself but in the psychological difficulty of adjusting to something unfamiliar (38).

The steps in teaching the metric system are:

1. Make an inventory of the knowledge, concepts, skills of employees, indicating what needs to be taught.

2. Gain knowledge of the early history of measurement and the need for uniformity.

3. Become familiar with the metric system of measurement, its development and growth. Clear concepts of the basic units should be obtained by bringing these units to study and use.

4. Understand the ease of operation with metric units and the advantages in its use.

5. Develop sufficient skill in the use of the metric units to serve one's needs and be able to mentally convert one measurement to another.

The elements of an educational program for a hospital dietary department could include the following:

1. Memo to staff informing them of the proposed change to the metric system and how it would affect them.

2. Distribution of conversion tables, explanatory materials, handbooks and metric training aids.

3. Lectures on the history, benefits and application.

4. Display posters strategically for advanced publicity prior to the actual changeover date.

5. Display new utensils and measuring devices.

6. Install 24 hour digital readout clock in cafeteria. Though not part of the metric system, the 24 hour clock is a predominant international standard which is useful in avoiding the confusion of a.m. and p.m. (14).

7. Emphasize target date and slogan.

The best way to "go metric" is to "think metric" without conversion. For the usual estimation or judging, one can think of a meter being a large yard, a liter being a large quart, and a kilogram being a couple of pounds. The emphasis should no longer be on teaching comparisons and conversions, but on the use of the metric system. The new language cannot be taught by teaching the vocabulary and grammar. Exact conversion tables have been shown through experience to retard acceptance of the metric system and they should be used as sparingly as possible, for the important part of training is to induce employees to " think metric " (39). The most effective way to learn the new language is to use it in meaningful, everyday experience. In addition, extensive preparation to train personnel properly and to make them a part of the program would make a more successful conversion.

Wandmacher (2) summarized the approach to conversion quite succintly:

"There is no need to master all aspects of the metric system at one time. It is best to select first a few landmark relationships from common experience appropriate to the individual case and use these consistently to build an International System of Units (SI) orientation and a relative sense of proportion."

METRIC SYSTEM TRAINING AIDS FOR FOOD SERVICE PERSONNEL

A series of lessons on the metric system for food service personnel was developed:

I. History and development of the metric system

II. Terminology and symbols in the metric system

III. Advantages of the metric system as compared with the U. S. Customary System

IV. Kitchen metrics

Each lesson contained objectives, approach, broad and supporting generalizations, and learning experiences with samples of visual aids.

Lesson I

Basic Concept: History and Development of the Metric System

Objective: The hospital dietary employee will be able, after the lecture, to relate orally the beginnings of both the U. S. Customary and Metric Systems and realize their different origin bases.

Approach: What did man first used to measure and weigh things with?

Broad Generalizations:

The earliest units of measurement were crude, indefinite, and inconsistent from country to country.

The metric system arose out of the confusion in 1790.

The metric system has spread internationally at a rapid pace, with 90% of the world's population adopting it today.

Supporting Generalizations	Learning Experiences
The customary system was a makeshift based largely on folkways. The units represented various dimensions of the human body.	Discuss how measures of length, weight, and volume might have developed.
The metric system was developed scientifically in France at the time of the French Revolution. The system was based primarily on the meter, and all other units were derived from it.	Discuss simply how the meter was established. Show a meter stick, decimeter cube to get an idea of how one unit is related to the other.
The metric system is used widely by scientists all over the world. Although its progress in the U. S. is slow, its future adoption is inevitable.	Show chart of its progress in the U. S. (Fig. 2).

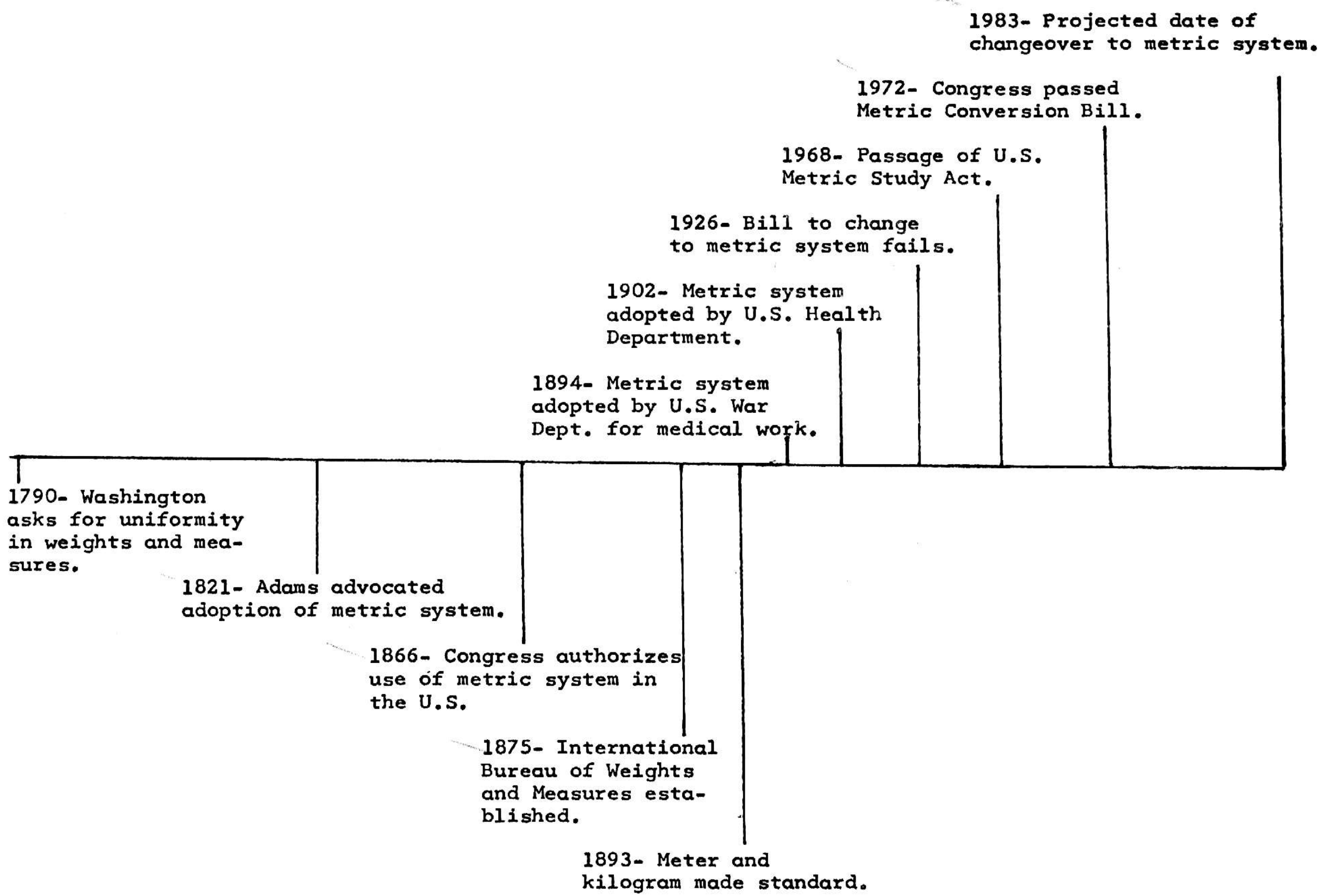


Figure 2. Progress of the metric system in the United States.

Lesson II

Basic Concept: Terminology and Symbols in the Metric System

Objective: The hospital dietary employee will be able to write and recognize common metric terminology and symbols.

Approach: There are less than 10 terms and symbols to remember in the metric system.

Broad Generalizations:

The metric system has a consistent naming scheme. Most metric terms are formed by using the basic unit as the root of the word, along with a prefix, which changes the main units to more conveniently sized units for specific purposes.

Approximations are helpful while in the process of being acquainted with the metric system.

Supporting Generalizations	Learning Experiences
The key unit is the meter. Anything that is considered in terms of weight is measured by divisions or multiples of a gram- the equivalent of a cubic centimeter of water at a certain temperature. Anything that is considered in terms of capacity, be it liquid or dry, is measured in terms of divisions or multiples of a liter- the equivalent of a cubic decimeter.	Show diagram of how the meter can be divided into units in divisions of ten (Fig. 3). Go through multiples and sub-multiples of each basic unit (Table 2). Show table with metric units and their relationships (Table 3).
Standard prefixes are added to give names for quantities of a particular unit that differ by multiples of ten.	Give a short quiz on the common prefixes and their meanings (Table 4). Briefly, give an idea of metric unit sizes by comparing with the customary system. Show graphs depicting relative sizes (Fig. 4, 5, 6).

The basic unit of length measurement is the meter. All other units are expressed as this base unit to a power of ten.

When the meter is divided into ten equal parts, each part is 1/10 of a meter and is called a decimeter.

When the meter is divided into 100 equal parts, each part is 1/100 of the meter or 1/10 of the decimeter and is called a centimeter.

When the meter is divided into 1000 equal parts, each part is 1/1000 of the meter or 1/10 of the centimeter and is called a millimeter.

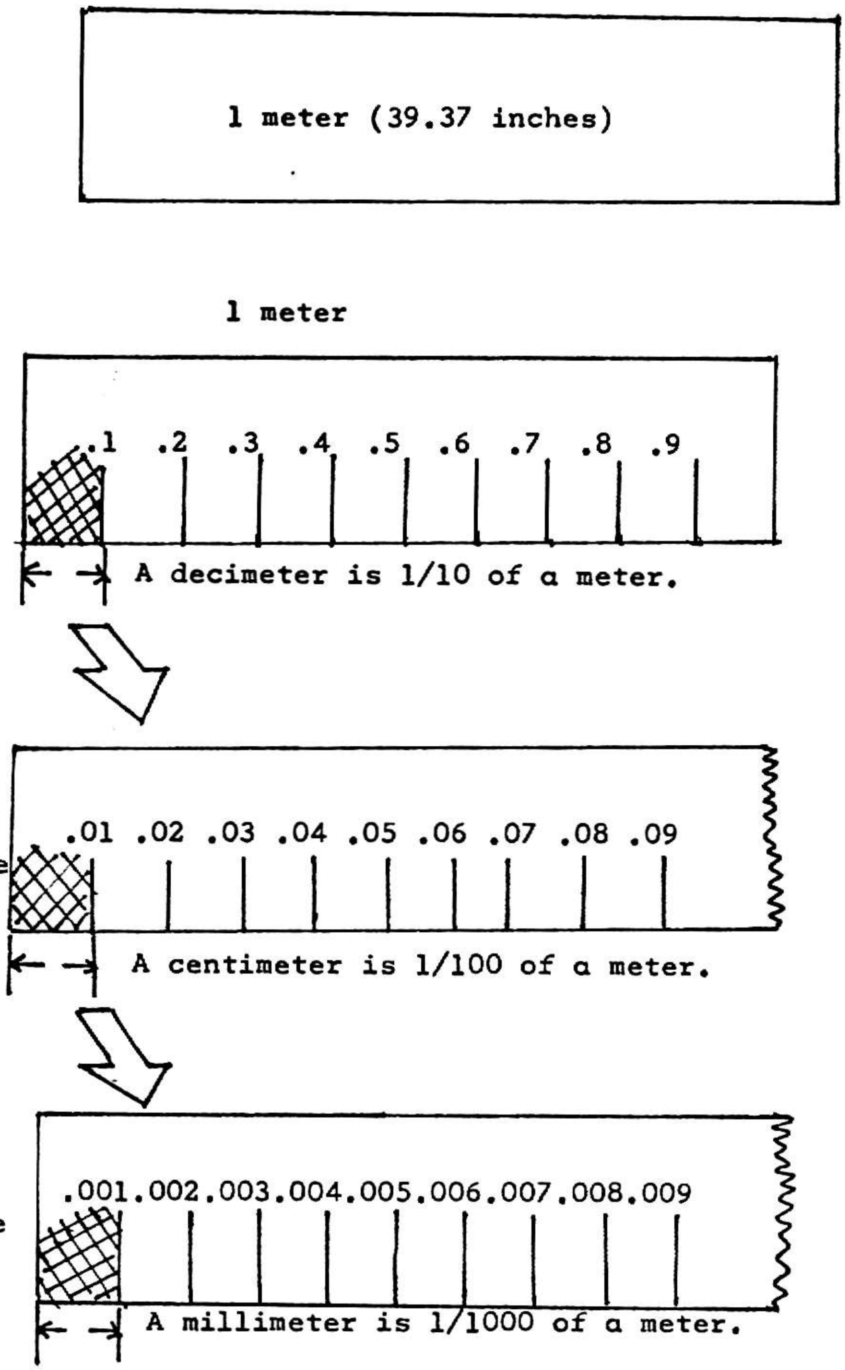


Figure 3. Decimal divisions of the meter.

Table 2. Multiples and submultiples of basic units.

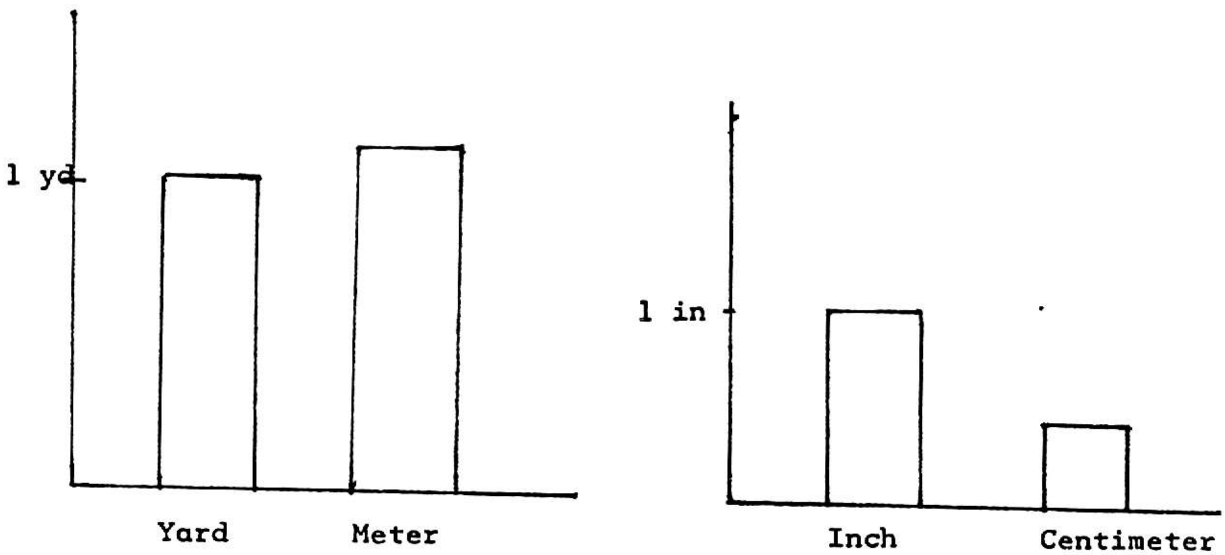
Measure	Unit	Submultiples	Multiples
Length	Meter	decimeter (1/10 meter)	dekameter (10 meters)
		centimeter (1/100 meter)	hectometer (100 meters)
		millimeter (1/1000 meter)	kilometer (1000 meters)
Weight	Gram	decigram (1/10 gram)	dekagram (10 grams)
		centigram (1/100 gram)	hectogram (100 grams)
		milligram (1/1000 gram)	kilogram (1000 grams)
		microgram (1/1,000,000 gram)	metric ton (1,000,000 grams)
Volume	Liter	milliliter (1/1000 liter)	

Table 3. Metric units and their relationship (40).

Unit	Symbol	Relationship
Length		
millimeter	mm	1000 mm = 1 m
centimeter	cm	100 cm = 1 m
decimeter	dm	10 dm = 1 m
meter	m	1000 m = 1 km
kilometer	km	
Area		
sq. centimeter	cm^2	
sq. meter	m^2	
Volume		
cubic centimeter	cm^3	1000 cm^3 (ml) = 1 dm^3 or l
milliliter	ml	
cubic decimeter	dm^3	1000 dm^3 (l) = 1 m^3
liter	l	
Weight		
microgram	μg	1000 μg = 1 mg
milligram	mg	1000 mg = 1 g
gram	g	1000 g = 1 kg
kilogram	kg	1000 kg = 1 t
metric ton	t	
Temperature		
degree Celsius	^{o}C	

Table 4. Common metric prefixes

Prefix	Meaning	Symbol
micro-	1/1,000,000	μ
milli-	1/1,000	m
centi-	1/100	c
deci-	1/10	d
deka-	x 10	dk
hecto-	x 100	h
kilo-	x 1,000	k
mega-	x 1,000,000	M



Relative size of yard and meter- 10% difference

1 yd = 0.9 m

1 in. = 2.54 cm

1 cm = 3/8 in.

Figure 4. Relative sizes of metric and U. S. Customary units of length.

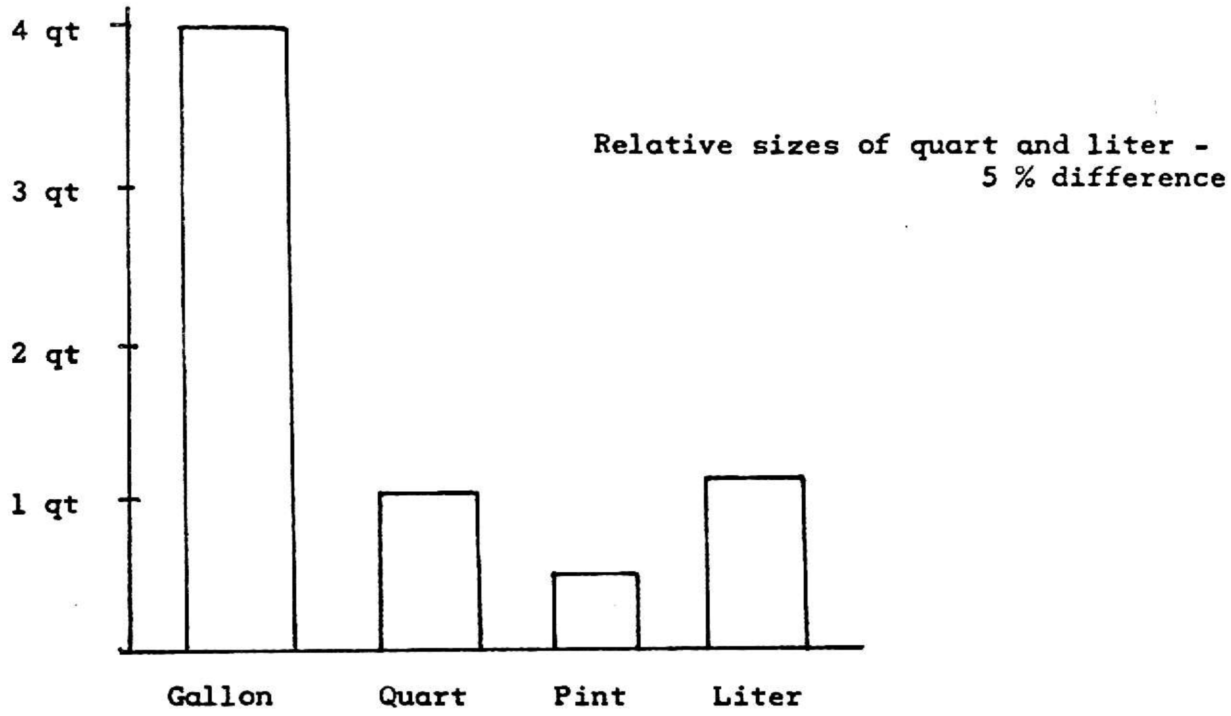
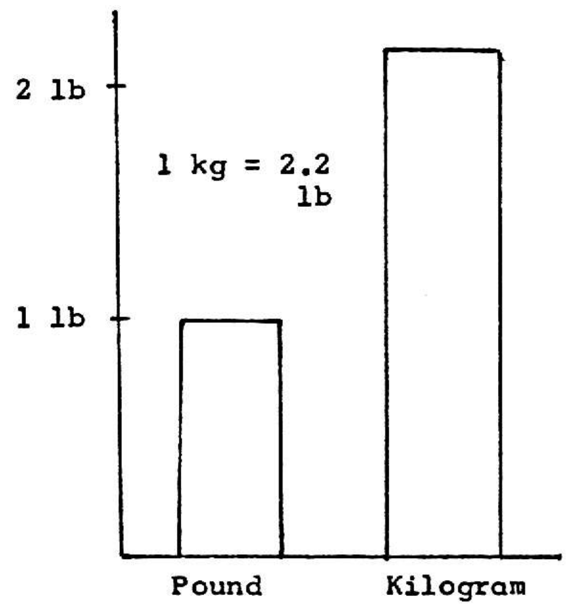


Figure 5. Relative sizes of metric and U. S. Customary units of liquid measure.



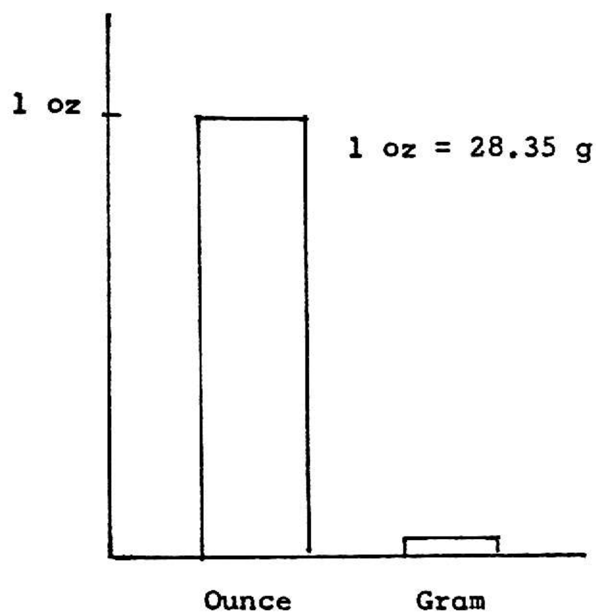


Figure 6. Relative sizes of metric and U. S. Customary units of weight.

Lesson III

Basic Concept: Advantages of the Metric System as Compared with the U. S. Customary System.

Objective: The hospital dietary employee will be able to understand and see the inherent simplicity of the metric system by doing calculations with both systems.

Approach: Discuss the U. S. standardized measures and ask if a pattern of progression can be seen in:

4 quarts in a gallon
2 pints in a quart
2 cups in a pint

Compare with the special pattern in the metric system:

10 mm = 1 cm
10 cm = 1 dm
10 dm = 1 m
10 m = 1dkm
10dkm = 1 hm
10 hm = 1 km

or

1000 mg = 1 g
1000 g = 1 kg

Broad Generalizations:

Unlike the U. S. Customary System, the metric system has a systematic nomenclature, without the duplication of names so often found in the customary system.

The risk of error in calculations is reduced when using the metric system. Computations would be simpler in determining per unit cost, number of portions, comparing prices, converting to a higher or lower unit, and mathematical operations.

Units of length, weight, and volume are related in a convenient way.

Supporting Generalizations	Learning Experiences
A comparison of the various units of measurement and their relationship will illustrate the simplicity of the metric system.	Compare the terminology and relationship in both systems (Table 5). Point out the duplication of names in the customary system: 2 lbs- troy, avoirdupois 3 ozs- troy, avoirdupois, liquid

Supporting Generalizations	Learning Experiences
	Bushel- a measure of capacity used also as a measure of weight.
Determining number of portions is much easier with the metric system than with the present system.	Show the speed with which number of portions can be obtained using both systems, for example: Customary: Determine how many 4 oz portions there are in a can containing 2 lb 8 oz. Metric: Determine how many 130 g portions there are in a can containing 780 g.
Price comparisons are simplified.	For example: Customary: Which is the better bargain- a large size box of 1 lb 7 oz for 59¢ or a giant economy size box of 2 lb 3 oz for 97¢ ? Metric: Compare the prices of a 700 g box at 59¢ and a 1050 g box at 89¢.
Extensive calculations are required in the customary system to convert units while all conversions go by multiples of 10 in the metric system. One has only to move decimal points by the proper number of places.	Do conversion exercises in both systems, for example: Customary: Convert 1 gal 3 qt 5 pt to pints. Metric: Convert 14.645 kg to grams.
Mathematical operations with the customary system is cumbersome.	Compare the simple operation of addition with both systems.
The units of length, capacity, and weight are interrelated and readily determined in terms of one or another in the metric system.	Show table explaining the interrelationship of units in the metric system and compare with those in the customary system (Table 6).

Table 5. Terminology in the metric and U. S. Customary systems (5).

	Length	Mass	Volume	Temperature	Electric Current	Time
Metric system	Meter	Kilogram	Liter	^{o}C	Ampere	Second
Customary system	Inch Foot Yard Fathom Rod Mile	Ounce Pound Ton Grain	Fluid ounce Teaspoon Tablespoon Cup Pint Quart Gallon Bushel Peck Barrel	^{o}F	Ampere	Second

Table 6. Interrelationship between metric units (40).

Side of Cube	Volume	Capacity	Weight of Volume of Water at 4°C
1 mm	1 mm^3	= 1 µl	1 mg
1 cm	1 cc	= 1 ml	1 g
10 cm = 1 dm	1 dm^3	= 1 l	1 kg
100 cm = 1 m	1 m^3	=10 hl	1 ton

Lesson IV

Basic Concept: Kitchen Metrics

Objective: The hospital dietary employee will be familiar with the uses of the metric system in the kitchen.

Approach: Nothing will be drastically changed, as metric units tie in very closely with the U. S. Customary System units.

Broad Generalizations:

Temperature, length, mass, and volume measures would be in terms of °C, centimeters or millimeters, grams or kilograms, and milliliters or liters, respectively.

The joule or kilojoule would be the fundamental unit of energy in nutrition and dietetics.

Though not a part of the metric system , the 24 hour clock system usually is introduced along with it, as it is useful in avoiding scheduling confusion.

Supporting Generalizations	Learning Experiences
Temperatures would be expressed in °C in oven controls, freezers, refrigerators, thermometers, and other electrical equipments.	Show temperature scale comparing degrees in both systems (Fig. 7) (Table 7).
The basic measure of length is the meter. In the kitchen, millimeters and centimeters are commonly used, as in cutting and shaping instructions in recipes, and pan sizes.	Display utensils with associated metric units.
The unit of weight is the kilogram, which is 1000 grams or a little over 2 pounds. Ounces will be replaced by grams.	Display new scales and balances.
Cup and spoon measures will be in liters or milliliters.	Display milliliters and liters measuring devices, metric cup and spoons.
The joule is a unit derived directly from the basic metric system units. It is supposed to replace the term calorie.	

Supporting Generalizations	Learning Experiences
The 24 hour clock is superior to the conventional clock as it avoids the confusion of a.m. and p.m.	Show figure of 24 hour clock and give examples of conventional time converted into 24 hour time (Fig. 8).

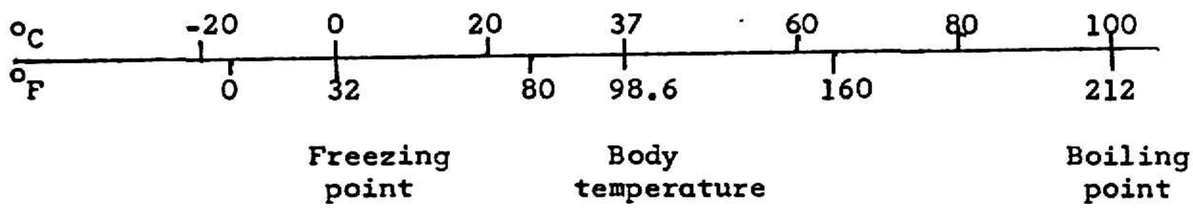
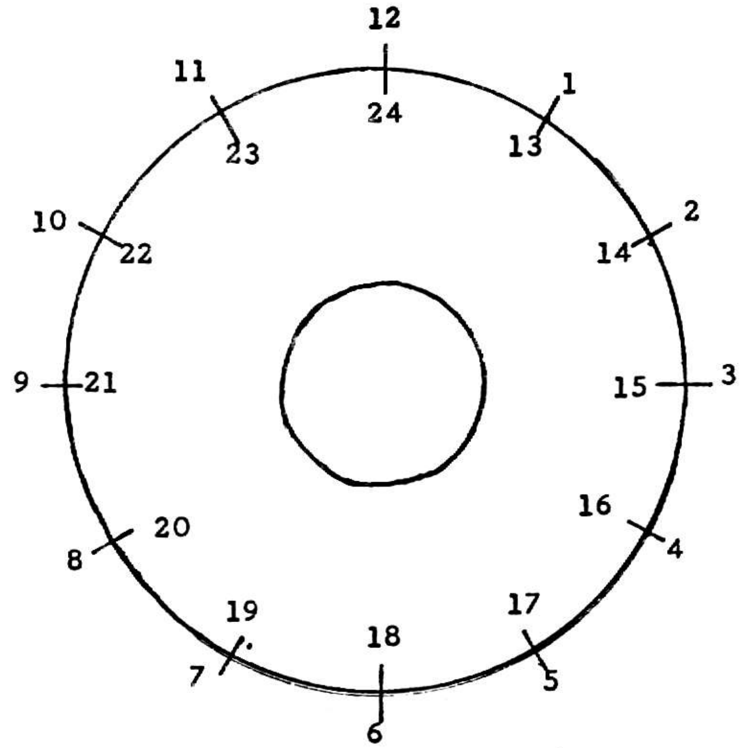


Figure 7. Temperature scale in °F and °C.

Table 7. Oven temperatures in °F and °C.

Terms	°F	°C
Very slow	250-275	121-135
Slow	300-325	149-163
Moderate	350-375	177-191
Hot	400-425	204-218
Very hot	450-475	232-246
Extremely hot	500-525	260-274



Conventional	24 hour	Change
12:01 a.m. (midnight) to 12:59 a.m.	00.01 to 00.59	12 → 0
1:00 a.m. to 12:59 p.m. (noon)	01.00 to 12.59	no change
1:00 p.m. to 12:00 midnight	13.00 to 24.00	add 12

Figure 8. The 24 hour clock system (40).

CONCLUSION

A changeover to the metric system no doubt will involve costs in retraining and in replacement of equipment and measuring devices. The cost is considered a wise investment as the temporary inconvenience in making the change is better than constant inconvenience under the present system.

A coordinated program would involve deliberate and careful change with a plan toward complete conversion on a target date, anticipating problems that may arise.

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REFERENCES CITED

1. Holden, C.: Ten year conversion plan. Sci. 173:613, 1971.

2. Phillips, D. F.: Metric system- Inching towards the meter. Hospitals. 46:49, 1972.

3. Miller, B. S. and Trimbo, H. B.: Use of metric measurements in food preparation. J. of Home Econ. 64:20, 1972.

4. Testimony of Nationally Representative Groups- U. S. Metric Study Interim Report. Ed. by Odom, J. B. NBS Spec. Publ. 345-12, U. S. Department of Commerce, NBS, Wash., D. C., 1971.

5. De Simone, D. V.: A Metric America- A Decision Whose Time Has Come. NBS Spec. Publ. 345, U. S. Department of Commerce, NBS, Wash., D. C., 1971.

6. Townsend, J. R.: Metric versus English systems. In: Systems of Units, National and International Aspects. A symposium organized by section M on engineering. Publ. No. 57 of AAAS, ed. by Kayan, C. F., 1958.

7. Whitcraft, L. H.: Teaching the metric system to prospective teachers. In: The Metric System of Weights and Measures. 20th yearbook of the National Council of Teachers of Mathematics. Compiled by the Committee on the Metric System. Johnson, J. T., Chairman. New York: AMS Reprint Co., 1966.

8. AHEA's involvement in the metric system study. J. of Home Econ. 62(6):419, 1970.

9. O'Neill, J. J.: Metric system's universal use urged as step to world peace. In: The Metric System of Weights and Measures. 20th yearbook of the National Council of Teachers of Mathematics. Compiled by the Committee on the Metric System. Johnson, J. T., Chairman. New York: AMS Reprint Co., 1966.

10. Warning, M.: Start now to think metric. J. of Home Econ. 64:18, 1972.

11. Whatever happened to the drive to put the U. S. on the metric system? U. S. News 14:53, 1973.

12. Buffalo Evening News. Buffalo, New York, Sept. 21, 1973, p.6.

13. Viets, L.: Experiences for metric missionaries. Arith. Teach. 20:269, 1973.

14. Frost, D. V., Helgren, F. J., and Sokol, L. F.: Metric Handbook for Hospitals. Metric Association, Inc., Illinois, 1971.

15. Metric Units of Measure. Booklet. Metric Association, Inc., Illinois, 1972.

16. Urbancek, J. J.: Later trends in metric usage. In: The Metric System of Weights and Measures. 20th yearbook of the National Council of Teachers of Mathematics. Compiled by the Committee on the Metric System. Johnson, J. T., Chairman. New York: AMS Reprint Co., 1966.

17. Kendig, F.: Coming of the metric system. Sat. Rev. 55:40, 1972.

18. Arnold, C. J.: The metric system: What it is and why we need it. In: The Metric System of Weights and Measures. 20th yearbook of the National Council of Teachers of Mathematics. Compiled by the Committee on the Metric System. Johnson, J. T., Chairman. New York: AMS Reprint Co., 1966.

19. Increasing the use of the metric system. Hearing before the Committee on Commerce, U. S. Senate, 90th Congress, U. S. Government Print. Off., Wash., D. C., 1968.

20. Phillips, J. A.: Purchasing processed foods. In: The Consumer- U. S. Metric Study Interim Report. NBS Spec. Publ. 345-7, U. S. Department of Commerce, NBS, Wash., D. C., 1971.

21. Merchant, M. M.: Purchasing fresh foods. In: The Consumer- U. S. Metric Study Interim Report. NBS Spec. Publ. 345-7, U. S. Department of Commerce, NBS, Wash., D. C., 1971.

22. Metric justification. Consumer Bull. 55:34, 1972.

23. Branscomb, L. M.: The U. S. metric study. Sci. Teach. 38:58, 1971.

24. Hunt, F. E. and Green, M. E.: Food preparation- Recipes and their conversion. In: The Consumer- U. S. Metric Study Interim Report. NBS Spec. Publ. 345-7, U. S. Department of Commerce, NBS, Wash., D. C., 1971.

25. Schlessinger, P. E. and Kennedy, B. M.: Metric measurements in food preparation. J. of Home Econ. 59(2):120, 1967.

26. American standard: Dimensions, tolerance, terminology for home cooking and baking utensils 261.6, American National Standards Institute, 1963.

27. Mills, N.: The metric revolution. Forecast for Home Econ. 15: F-28, 1969.

28. Ratcliff, J. D.: Let's go metric. In: The Metric System of Weights and Measures. 20th yearbook of the National Council of Teachers of Mathematics. Compiled by the Committee on the Metric System. Johnson, J. T., Chairman. New York: AMS Reprint Co., 1966.

29. Lawson, R. E.: A hospital's conversion to the metric system. Hosp. Pharm. 1(10):35, 1966.

30. Goetz, H. M.: Purchase and use of kitchen equipment. In: The Consumer- U. S. Metric Study Interim Report. NBS Spec. Publ. 345-7, U. S. Department of Commerce, NBS, Wash., D. C., 1971.

31. Toward a 1024 joule hamburger. Sci. Am. 226:56, 1972.

32. Ames, S. R.: The joule- Unit of energy. J. Am. Dietet. A. 57: 415, 1970.

33. Editorial. To count calories or to juggle joules. J. Am. Med. A. 219(9):1206, 1972.

34. Harper, A. E.: Remarks on the joule. J. Am. Dietet. A. 57:416, 1970.

35. Metric units, conversion factors and nomenclature in nutrition and food sciences. Nutr. Soc. Proc. 31:239, 1972.

36. Moore, T.: Joule versus calorie as the fundamental unit in nutrition. Royal Soc. of Health J. 90:112, 1970.

37. Vickers, C. T. S.: Making the Most of Metrication. London: Gower Press, 1969.

38. Report of the National Metric Study Conference- Consumer affairs. J. of Home Econ. 63(5):346, 1971.

39. Donovan, F. R.: Prepare Now for a Metric Future. New York: Weybright and Talley, 1970.

40. Mettler, A.: Metric Handbook for Hospital Staff. Ontario: Renown Printing Co. Ltd., 1969.

METRIC SYSTEM CONVERSION FOR HOSPITAL DIETARY DEPARTMENTS

by

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B. S., University of the Philippines, 1970

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Institutional Management

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1973

ABSTRACT

According to statistics, 90% of the world's population is using the metric system. The switch is inevitable for the United States, as the Senate has overwhelmingly approved a ten-year conversion period.

Hospital dietary departments should start to consider problems of conversion and to make appropriate plans for conversion with the least amount of inconvenience, confusion, and cost.

Basically, the metric system has three main units- meter, liter, and gram- and these can be changed by means of a consistent system of prefixes to conveniently sized units for specific purposes. Compared with the U. S. Customary System, it is a scientific system, with consistent and logical relationship between consecutive units and a systematic nomenclature.

Hospital dietary departments probably would face more software changes than hardware. Increased metrication would be of benefit in the areas of purchasing and food preparation. Changes would occur in the measurements of temperature, mass, capacity, and length, with the use of metric measuring devices. Recipes may require revision where straight conversions would upset the balance of ingredients. No foreseeable confusion would arise as to equipment changes as items could be converted on an attrition basis. The practice of using the calorie might be continued although in general the only energy unit to be used will be the joule.

The greatest problem in the changeover is in the psychological difficulty of adjusting to something new and unfamiliar. This in large part involves the proper education and training of those who will encounter it in everyday use.

A series of lessons on the metric system for food service employees was developed for the report. Included were the history and development of the metric system, its basic fundamentals, advantages of its use, and practical kitchen metrics.