

A case series of over-hydration in making baby formula -Importance of the metric system.

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Abstract

Over-hydration is a serious concern when making formula for infants. If the formula is not made according to the instructions because the wrong amount of formula is used in relationship to the volume of water added, the infant could experience life threatening changes. Understanding the difference between US fluid ounces (US fl oz) and UK fluid ounces (UK fl oz) was the objective of this case. Baby formula and breast feeding have been a topic of discussion in the media. Based on this case we are able to promote dialogue and critical analysis of the risk and benefits of formula feeding as compared to breastfeeding.

Keywords: Metric system, Over-hydration, Breastfeeding, Infant feeding, Formula feeding, Lactation.

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Introduction

There is continuous conversation and growing controversy of the need and use of baby formula in America. In 1992 a longitudinal study of the Infant Feed Practices Study II (IFPS II) was conducted by the US Food and Drug Administration to get a better understand of the general nutritional patterns of infants in the first year of life [1]. Despite some societal negatives associated with breastfeeding, a number of studies have been conducted and concluded that babies born in industrialized countries, and are not breastfeed, have a higher incident of respiratory infections and almost twice as likely to form ear infections [2]. The American Academy of Pediatrics now recommends that mothers breastfeed excessively at a minimum the first six months of life and if possible for the first year of a baby's life. Despite this specific recommendation, a small percentage of US infants are breastfeed at 3 months and only 21% for 1 year of life [2-3]. There are many contributing factors to these low numbers. One idea supported by the literature is the lack of social acceptance. There have been a number of documented negative encounters experienced by lactating mothers, for example people have repeatedly reported that women have been told to feed their children in the bathroom and away from public view [4].

In 2008, Jacqueline Wolf made the following observation,

“America's focus on the sexual purpose of breasts, rather than the physiological function of breasts, has serious public health consequences. Discomfort with breastfeeding in public lowers breastfeeding rates, which in turn negatively affects women's and children's short- and long-term health” [5]. So because a myriad of reasons, American mothers are heavily reliant on bottle feeding. Thus, making sure that all aspects of bottle formula making is understood is critical for a healthy baby.

Lactation Process in Humans

Human milk is unique and complex. It has a complex immunology and the early milk provide colostrum which has a low concentration of fat but a high concentration of protein and minerals for the new infant. The process by which is created has been studied. The stages of lactation are summarized in Table 1 [6]. An excellent explanation of each stage is provided by Wagner et al. [7].

History of Formula

The creation of formula is a prime example of “better life, through better chemistry.” In the 18th century, the first chemical analyses of human milk and animal's milk was accomplished. In 1760, Charles Des-Essartz published the Treatise of Physical Upbringing of Children [8,9]. In this Treatise he published a composition comparing human milk to cow, sheep, jackass,

Table 1: Stages of the lactation process, location and physiological changes.

Process	Location	Physiology
Mammogenesis	Mammary tissue growth	The size and weight of breast usually increases
Lactation	Occurs in two stages. In the late states Endocrine system controls the flow and production of milk.	Stage 1 – Last trimester Alveolar cells differentiate from secretory cells.
		Stage 2 – up to 1 week after birth; breast are full and can become engorged.
Galactopoiesis	Secretion is maintained; Autocrine system controls continuation of lactation	Occurs 9 days after birth and continues to involution
Involution	Milk production is inhibited by peptides	Usually 30-40 days after last breastfeeding.

mare and goat. It is interesting that without having knowledge of the genetics these animals were studied. Using modern molecular techniques a phylogenetic relationship of the milk protein in these organisms has been demonstrated by Cunsolo et al. [10]

In 1865, the first baby formula was patented by Justus von Liebig [11]. The creation of a baby formula at the end of the Civil War was rather fortuitous. Up until that time, white plantation owners, in particular in the Antebellum South depended upon “wet nurses” to suckle infant babies. For whatever, psychosocial reason, breastfeeding was a task left to slaves and not the biological, white woman. In some accounts, in Europe wet nurses was not favored because it was believed that the child could inherit the genetics of the wet nurse [11]. So there was a certain stigma to having someone other than the mother suckle the child. However, in the colonies there is support that having a “wet nurse” became a badge of honor and not shame. It was the role of the “mammie” to nurse the child and not the birth mother [12].

In the early 20th century, breast milk was looked upon as a questionable choice. Eventually, many companies were created around baby food. The baby food industry became a billion dollar industry. Early on in the development of the baby food industry there was basic misunderstanding in the proper use of baby formula. The verging industry increased its relevance by working with the government to provide insight as to why so many babies died. Most of the deaths were because of the lack of clean utensils and or proper sterilization of the bottles. By the 1940s the government and the private sector had put great effort in figuring out what caused babies to die [13]. Powder formula was conquered when it was realized that adding water only as needed lead to a safer product. The use of formula grew at a steady increase as breastfeeding was on a steady decline.

In 1974 the public became outraged by Nestlé’s International Campaign with their undocumented conclusions. Some supports of formula pointed to the fact that in addition to the many benefits that are available in milk there was also the possibility of mother’s passing on disease through their breast milk. Mead (2008) outlines some of the risk that are associated with breastfeeding when the mother has been exposed to alcohol, tobacco, pesticides and heavy metals that can concentrate in the breast tissues and eventually become a part of the breast milk [14]. However, studies by the University of North Carolina in Chapel Hill’s Global Breastfeeding Institute supports the idea that the benefit of mother’s milk is more beneficial than a risk. However, the Institute has specific recommendations for women who are HIV positive and or who present with lesions from Herpes Simplex but the take home message is that in most cases mother’s milk presents very low risk for the nursing [15].

Breast Feeding As a Human Right - It is amazing that despite the health benefits that have been clearly demonstrated for breastfeeding that in 21st century United States there is considerable pushback against mother’s nursing in public spaces. A number of strategies have been adopted to help people to become more comfortable with the idea of breastfeeding. In 2009, the Marin Breastfeeding Coalition (Marin County, California) placed life size cutouts of mother breastfeeding

in public locations to help destigmatize and normalizing the idea of breastfeeding in public [16]. Similar campaigns have been launched in Australia and Canada. The WHO and UNICEF also recognizes breastfeeding as a global health issue and supports the need to reinforce it as a basic human right [17]. Although this additional campaigns have been introduced to the public with life size portraits of women, it has been recognized that men must be educated as women are empowered. Only one side of the issue is being addressed if the focus is only on women. Fathers holding their children, and various family photos displaying family units were introduced to widen the conversation. The issue is not a “women, infants and children” (WIC) issue [13]. It is a family and human rights issue. The outcomes have social and economic consequences for humanity.

Case Report

Clinical case - Miscalculation of baby formula

Maximus was an 8-month old baby boy. He was born in the United States on February during “Superbowl” Sunday. At birth he weighed 10 lbs. He was breastfed with occasional supplementing with baby formula. He had a healthy appetite and did not mind being fed from the bottle. When Maximus was 7 months old he and his parents visited Tanzania. He went to visit his paternal grandparents. While he was in Tanzania, his parents purchased a baby bottle for him. They also had to purchase formula for him while in Tanzania.

When they returned to the United States, Maximus went to visit his grandmother in Virginia. He was eating some baby cereals, but his primary food source was milk. His grandma in Virginia kept him for two weeks. His parents brought the “Tanzanian baby bottle” and the formula. The formula did not last for the two weeks so his grandmother went to the local grocery store and purchased a new powder formula. When it was time for Maximus’ next feeding, his grandma immediately, noticed that the milk looked differently. But she was sure she followed the directions (i.e., 3 scoops for 6 fl oz). But the milk did not look the same as before. And baby Maximus started to have some issues after a day or so with being fussy. His diapers content looked differently. Grandma was totally suspicious of the milk and if she had made it correctly. It had been more than 25 years since she had made formula so she was almost sure that it had to be the formula.

So re-evaluating the steps in the process of formula making. The first think she noticed was that the bottle had three different measurements (Figure 1). The US fluid ounces and the UK fluid ounces, in addition to milliliters. Then she went to the formula can and noticed that the formula was purchased in the UK and she was using UK fluid ounces with the US measurements for “scoops.” The milk was too dilute. On average she adding about 30 mL more water for each feeding. She used Google to find support for her hypothesis and she was able to find a blog where other parents had similar experiences:

“... you need to use mL not oz. A UK fl oz is 28 mL not 30 mL. I think US fl. oz is 30 mL.”

“[Y]es, I noticed this and do it the same as you to the mL instead of hte (sic) oz. Also, I have a bottle that has [A]merican oz on



Figure 1. Example of the types of baby bottles used to make the formula. (Noticed on the far left the measure is in mL and on the right-hand side it has both US and UK fl. Oz).

as well and they are different to [E]nglish ounces!!! [M]adness!
- [Accessed: August 2016 from <https://www.mumsnet.com/>]
[18].

Once reading the dialogue she immediately realized her problem. It was easier enough to fix. The more grandma research the topic, the more she understood the importance of knowing the metric system. If she had simply used mL on the bottle and on the instructions she could have avoided a fussy baby. In reading about this problem grandma ran across an article titled, “A history of Infant Feeding” [19]. The article provided the evolution of baby formula in the United States.

Results

This case series describes the importance of understanding labels and what the nutritional consequences are if baby’s formula is not mixed properly. Baby formula is expensive. In the United States in 2017, it was estimated that 30 or more ounces per day of baby formula (i.e., 30 fluid ounces is equivalent to 887 mL) cost \$3000 per year (or \$250.00 per month) [20]. Babies like Maximus easily consumed more than 887 mL’s in a day. At the height of his growth curve he was consuming 1.5 mL of formula a day. So often when parents are feeling a tight budget they are tempted to water down the formula. Too much water is dangerous for infants. Babies do not have the ability to process water out of their bodies until they are at least 10 months old, and too much water can dilute their blood and interfere with their electrolytes, causing sodium and potassium levels to plummet and possibly resulting in brain damage or seizures. This problem of over-diluting is not only seen in the US but over-diluting formula is a contributing factor to high morbidity and mortality among infants and young children worldwide. Over-diluted formula is often related to financial constraints: however, misunderstanding of the manufactures instructions, errors in scoop measurements as well as the liquid volume unit being wrong can all be contributing factors to making infant formula incorrectly [21].

The grandmother recognized that the formula did not look correct. This is not always something that can be easily noticed

especially for the new parent. In addition, baby Maximus was extremely fussy. His behavior change was enough to bring attention to the grandmother to do additional investigation as to the problem. Over-hydration or water intoxication is a condition in which the body contains too much water. The brain is the organ most vulnerable to the effects of over-hydration. If excess fluid levels accumulate gradually, the brain may be able to adapt to them, and the person will have only a few symptoms. If the condition develops rapidly, confusion, seizures, and coma are likely to occur.

Discussion

Generally, people do not consider the differences between US fl oz and UK fl oz. Besides not know the difference they often will confuse ounce mass with fluid oz. In 1795 the Paris Academy of Sciences adopted the metric system. The US Congress legalized the use of the metric system 90 years after the American Revolution for Independence. In 4 years after congressed legalized the measure, the US along with sixteen other nations established the Convention of the Meter. These conventions and those similar to the Paris Agreement of 2014 are critical to science and technology advancement. Countries have to speak the same language if they are to be trading partners in particular. As Sigmund Freud stated “It is impossible to escape the impression that people commonly use[d] false standards of measurement — that they seek power, success and wealth for themselves and admire them in others, and that they underestimate what is of true value in life”[22]. The use of the metric system which is designed on base 10 makes for the expected measurement to be exactly that and not for an ounce to mean an ounce no matter if you are in the United States or in the United Kingdom.

Conclusion

The idea of breastfeeding being a human right is very much a topic of discussion that is lacking in the United States. This case is able to address some critical concepts and allow for mature discussion on issues germane to the health of women and children. The case allows for the critical analysis of the

numerical data but in the context of human biology. This case would be ideal in a laboratory class of 20-24 students. We use this case at the beginning of the semester to help enforce the importance of the metric system in biology and the additive effect of consistent errors in measurements.

References

1. Fein SB, Labiner-Wolfe J, Shealy K, et al. Infant feed practices study II: Study methods. *Pediatrics*. 2008;122:28-35.
2. Mead MN. Contaminants in human milk: Weighing the risks against the benefits of breastfeeding. *Environmental Health Perspectives*. 2008;116:426-434.
3. Karmaus W, Soto-Ramírez N, Zhang H. Infant feeding pattern in the first six months of age in USA: A follow-up study. *International Breastfeeding Journal*. 2017;12:48.
4. Lynne J. Hector Cruz: The unlikely breastfeeding advocate. 2014. Retrieved from <http://www.iamnotthebabysitter.com/unlikely-breastfeeding-advocate/>
5. Wolf JH. Debate – Got milk? Not in Public! *International Breastfeeding Journal*. 2008;3:11
6. Riordan J, Auerbach KG. *Breastfeeding and human lactation*. Boston, Mass: Jones and Bartlett Publishers. 1993.
7. Shu XO, Linet MS, Steinbuch M, et al. Breast-feeding and risk of childhood acute leukemia. *Journal of the National Cancer Institute*. 1999;91:1765-72.
8. Helvenston S. Advice to American Mothers on the Subject of Children's Dress: 1800-1920. *Dress*. 1981;7:30-46.
9. Stevens EE, Patrick TE, Pickler R. A history of infant feeding. *The Journal of Perinatal Education*. 2009;18:32-39.
10. Cunsolo V, Muccilli V, Saletti R, et al. Applications of mass spectrometry techniques in the investigation of milk proteome. *Eur J Mass Spectrom*. 2011;17:305-320.
11. Cheema RK. Justus von Liebig: Momentous birth of infant formula. 2017. Retrieved from <https://today.mims.com/justus-von-liebig-momentous-birth-of-the-infant-formula>.
12. West E, Knight RJ. Mothers' Milk: Slavery, wet-nursing, and Black and White women in the Antebellum South. *Journal of Southern History*. 2017;83:37-68.
13. Fry E. "Readability formula that saves time." *Journal of Reading*. 1986;11:512-516.
14. Mead MN. Contaminants in human milk: Weighing the risks against the benefits of breastfeeding. *Environmental Health Perspectives*. 2008;116:426-434.
15. Kastleman L. Breastfeeding: good for babies, good for moms. 2009. Retrieved from <http://www.sph.unc.edu/cph>.
16. Farooq S. New breastfeeding campaign turns heads. 2009. Retrieved from <http://www.nbcbayarea.com/news/weird/Lactating-Women-Getting-Second-Looks-in-Marin.html>
17. Labbok M, Nakaji E. Breastfeeding: A biological, ecological, and human rights imperative for global health. In: Murthy P, Smith CL, editors. *Women's Global Health and Human Rights*. Sudbury (MA): Jones and Bartlett. 2009;421-36.
18. Reid L, Ellsworth-Krebs K. Practicing energy prosumption: Using unsolicited online data to reveal the everyday realities of solar thermal panels in the United Kingdom. *Energy Research & Social Science*. 2017;34:191-9.
19. Stevens EE, Patrick TE, Pickler R. A history of infant feeding. *The Journal of Perinatal Education*. 2009;18:32-39.
20. Monahan E. What are the dangers of dilute formula? 2017. Retrieved <https://www.livestrong.com/article/97662-dangers-diluted-baby-formula/>
21. Andresen E, Rollins NC, Sturm AW, et al. Bacterial contamination and over-dilution of commercial infant formula prepared by HIV-Infected Mothers in a Prevention of Mother-to-Child Transmission (PMTCT) Programme, South Africa. *Journal of Tropical Pediatrics*. 2007;53:409-414.
22. Ucko P. Unprovenanced material culture and Freud's collection of antiquities. *Journal of Material Culture*. 2001;6:269-322.

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