Milk, Milk Fat, and Human Health: Challenging Popular Misperceptions

Adam L. Lock, Ph.D.
Michigan State University
Email: allock@msu.edu

INTRODUCTION

The importance of animal products in meeting global needs for food security is well established, and public health organizations around the world include milk and other dairy products in recommendations for a healthy, well-balanced diet. Dairy products are an important source for many vital nutrients including high quality protein, energy, and many essential minerals and vitamins (Bauman and Capper, 2011). Dairy products, however are also a major food source of saturated fat, accounting for 20 - 30 % of the saturated fat intake for the US population (USDA/USDHHS, 2010). For over a half-century, saturated fat has been demonized as the major cause of cardiovascular disease (**CVD**) and public health recommendations are to reduce dietary intake of saturated fat and food products containing saturated fatty acids (**FA**). As a consequence, the perception of the public, and much of the scientific community, is that milk fat is a negative component of dairy products and typical dietary advice is to consume only reduced-fat or no-fat dairy products. Recent estimates indicate that approximately 30 % of our dietary intake of saturated fat comes from dairy products with cheese being the major source (Ervin et al., 2004).

The term CVD includes coronary heart disease, cerebrovascular disease, and other related disorders of the heart and blood vessels. Cardiovascular disease is the leading cause of death in the US and globally, accounting for about one-third of all deaths (Roger et al., 2011). Strategies to reduce CVD involve reducing leading risk factors that include smoking, hypertension, and high cholesterol; doing so reduces the burden of CVD. The U.S. Center for Disease Control estimates that about 50 % of the US population has at least one of these three risk factors with CVD-related health care costs in the US at over $400 billion annually (CDC, 2011).

New research and re-evaluation of previous research is challenging long-held dogma on the relationship between saturated fat, milk fat, and CVD. While national organizations, health professionals, and dieticians will be cautious in revising decade-old recommendations; there is no doubt that the last few years have provided game-changing scientific evidence that will revise the paradigm for the connection between saturated fat and CVD. Furthermore, these new studies and re-evaluations have convincingly demonstrated the important role that milk and dairy products play in health maintenance and the prevention of chronic diseases. In the following sections we will deal briefly with some background and historical aspects related to saturated fat and CVD, and then highlight recent findings related to the role of milk and milk fat in human health.

BACKGROUND AND HISTORICAL ASPECTS

Milk fat is a complex mixture of saturated and unsaturated FA and varies according to breed, season, stage of lactation, and nutrition of dairy cattle

(Figure 1). The impact of nutrition on fat content and FA composition of milk has been extensively reviewed (e.g. Lock and Bauman, 2004). Due to increased consumer awareness of the link between diet and health, research has focused on altering the fatty acid composition of cows' milk to achieve a FA profile consistent with consumer perceptions and health recommendations. In the past, much of this work has involved studies in which whole-scale changes have been the goal; whereby large shifts in the saturated to polyunsaturated fatty acid (**PUFA**) ratio have been sought. Modest changes have been achievable, but this can lead to problems relating to product quality and stability. More recently, the amount of omega-3 FA in milk, in particular 20:5 n-3 (eicosapentaenoic, **EPA**) and 22:6 n-3 (docosahexaenoic, **DHA**), have been of interest as they are beneficial in the maintenance of human health and prevention of chronic diseases. Enhancing their content in milk requires an understanding of the interrelationship between dietary supply of FA, rumen fermentation, and mammary gland synthesis. Modest changes have been achievable, and in some markets specialty milk and dairy products are currently available that have been enriched with EPA and DHA. Claims of large percentage increases in omega-3 FA in dairy products should, however, be considered with caution due to their initial very low levels. Opportunities for greater enrichment of omega-3 FA will likely rely on post-harvest fortification of milk, if deemed desirable.

Ancil Keys (University of Minnesota) played a central role in labeling dietary fat, specifically saturated fat, as a major public health concern for CVD. Using population data obtained from World Health Organization (**WHO**) reports, Keys (1953) reported a curvilinear relationship between the intake of fat and deaths from coronary heart disease for six countries (open circles in Figure 2). Keys was featured on the cover of TIME magazine and this was the beginning of the *diet-heart hypothesis* proposing a sequence of etiologic relationships between dietary saturated fat, circulating cholesterol, and the development of CVD. Yerushalmy and Hilleboe (1957), however examined the publication by Keys (1953) and concluded that many aspects were flawed including the fact that the 6 countries had been cherry-picked from a data set for 22 countries (Figure 2). This represented an extraordinary critique, and based on a rigorous analysis of Keys' publication, they concluded *"The association between the percent of fat calories available for consumption in national diets and degenerative heart disease (reported by Keys) is not valid; the association is specific neither for dietary fat nor for heart disease mortality"* (Yerushalmy and Hilleboe, 1957). Despite this, Keys (1980) continued promoting the diet-heart hypothesis and followed-up with a seven country comparison showing that dietary intake of saturated fat as a percentage of calories was strongly correlated with coronary death rates (r = 0.84). Again, other scientists pointed out major flaws in his study, e.g. countries chosen by Keys to represent low saturated fat intake and low incidence of CVD were in fact less industrialized and differed in many ways including smoking habits, physical activity, and obesity (Willett, 2012). Nevertheless, the diet-heart hypothesis was well received by many health practitioners and policy makers.

Historically, serum cholesterol has served as a surrogate marker for the risk of CVD. Low-density lipoprotein cholesterol (**LDL-C**) is correlated with risk of CVD;

thus, the discovery that saturated fat resulted in an increase in LDL-C provided support for the diet-heart hypothesis, and some concluded that saturated fat must be the major cause of CVD (Ordovas, 2005). This particularly impacted public perception of dairy products because dairy fat contains 60 to 70 % saturated FA (Figure 1). Additionally, it was discovered that individual FA differ in their effects on serum LDL-C; whereas most saturated FA were neutral, lauric acid (C12:0), myristic acid (C14:0), and palmitic acid (C16:0) caused pronounced increases in LDL-C (Hegsted et al., 1965) and these three FA represent about 40 % of total milk fat (Figure 1). This led to the development of an atherogenic index which ranked foods based on their content of these three FA (Ulbricht and Southgate, 1991); needless to say, the atherogenetic index ranked dairy products as problematic with respect to CVD risk.

Public health recommendations in the 1970s and 1980s were to dramatically reduce the intake of saturated fat. This included recommendations to reduce intake of dairy products and/or a shift to low-fat or no-fat dairy products. One specific recommendation was to replace butter with margarine, and this was particularly unfortunate as it markedly increased the risk of CVD for millions of people. During this era margarine had high levels of *trans*-FA and subsequent research has established that intake of industrial sources of *trans*-FA are a major risk for CVD (Gebauer et al., 2011; Lock and Bauman, 2011). Much of the case against dairy foods is linked to an imperfect understanding of cholesterol as a surrogate marker of CVD risk. In addition to effects on LDL-C, saturated FA, in particular lauric acid, myristic acid, and palmitic acid cause an increase in serum high-density lipoprotein-cholesterol (**HDL-C**) and this cholesterol fraction reduces the risk of CVD. Thus, when changes in both LDL-C and HDL-C are considered, saturated FA have no adverse effect on serum cholesterol as a risk factor for the incidence of CVD. A meta-analysis by Mensink et al. (2003)

Figure 1. Fatty acid composition of retail milk samples in the United States. Adapted from O'Donnell-Megaro et al. (2011). Milk samples were obtained from 56 milk processing plants representing all US regions and seasons over a 12 mo period.
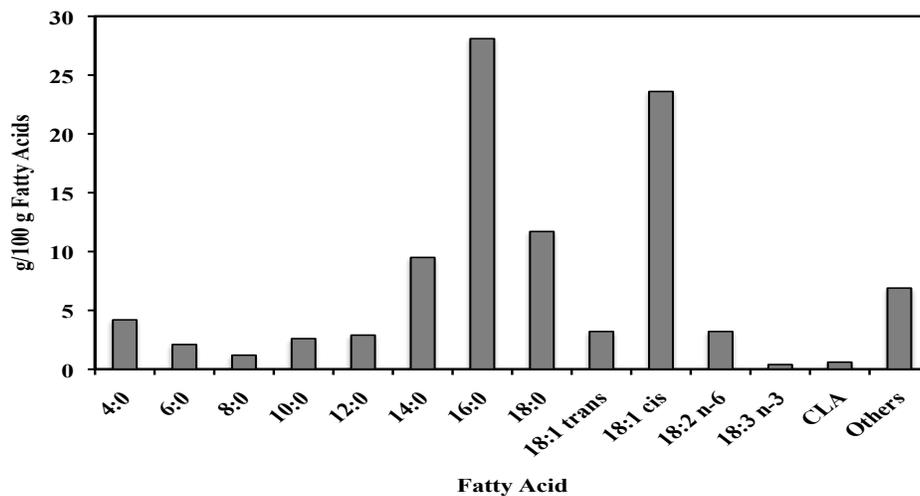
provides convincing evidence for this; using data from 60 clinical studies, they evaluated CVD risk on the basis of ratio of serum total cholesterol:HDL-C. As illustrated in Figure 3, ratios for lauric acid, myristic acid, and palmitic acid provide little or no evidence for an atherogenic effect when compared to an isoenergetic carbohydrate substitution; in fact the ratio for lauric acid was significantly decreased. When compared by fat type, the meta-analysis revealed no effect of saturated FA when compared to carbohydrate substitution on an isoenergetic basis (Figure 3). Nonetheless, changes in the ratio of serum total cholesterol:HDL-C were indicative of the well-established beneficial effects of monosaturated and polyunsaturated FA and the increased atherogenic risk of *trans*-FA. Thus, this classic meta-analysis utilizing cholesterol-related surrogate markers provides no support for saturated fat in general or the major individual saturated FA in milk fat as risk factors in CVD.

For the last 50 yr medical societies and government agencies have embraced the concept that nutrition, specifically saturated fat, is a major player in the epidemic of CVD. As discussed previously, the diet-heart hypothesis and the use of LDL-C as a surrogate marker were perceived to offer support for this concept. Acceptance by the scientific community, however, was far from unanimous (e.g. Ravnskov, 2002; Weinberg, 2004; Ordovas, 2005) and a growing body of scientific studies offered no support (see discussion in Lock and Bauman, 2011). The classic study by Mensink et al. (2003) discussed above was of special importance in challenging the dogma on the relationship between dietary saturated fat, serum cholesterol, and incidence of CVD. An

important recent investigation was that by Siri-Tarino et al. (2010). This meta-analysis of 21 prospective epidemiologic studies covered a 5 to 23 yr follow-up of 347,747 subjects and again results indicated *"there is no significant evidence that dietary saturated fat is associated with an increased risk of coronary heart disease or CVD"* (Siri-Tarino et al., 2010). Clearly, the relationship of fats including saturated fats, cholesterol, and CVD is more complex than initially thought and the risk of CVD is multifaceted.
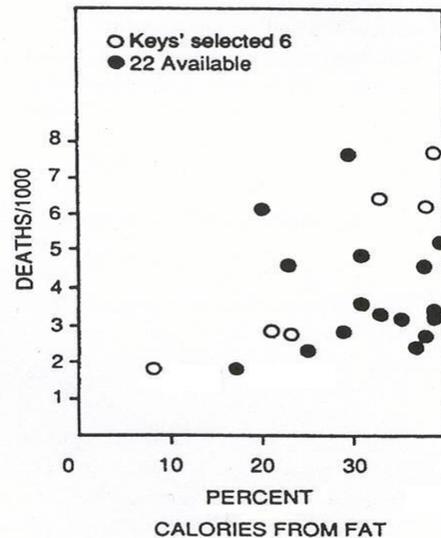

Figure 2. Relationship between percent of calories from fat and mortality from atherosclerotic and degenerative heart disease. Six countries (open circles) were selected by Keys (1953) from a WHO data set for 22 countries (unselected countries shown by solid circles). Adapted from Yerushalmy and Hilleboe (1957) and Maijala (2000). Relationship for the six selected countries represented the foundation for Keys diet-heart hypothesis to explain cause of cardiovascular disease.

Figure 3. Meta-analysis (n = 60 trials) to examine changes in serum ratio of total cholesterol to HDL-cholesterol when carbohydrates constituting 1 % of energy are replaced isoenergetically with fatty acids (Mensink et al., 2003). Panel A represents comparison of saturated, *cis*-monounsaturated, *cis*-polyunsaturated, and *trans*-monounsaturated fatty acids (*=P < 0.05; ¥=P < 0.001). Panel B represents comparison of lauric acid (12:0), myristic acid (14:0), palmitic acid (16:0), and stearic acid (18:0) (*=P < 0.001).
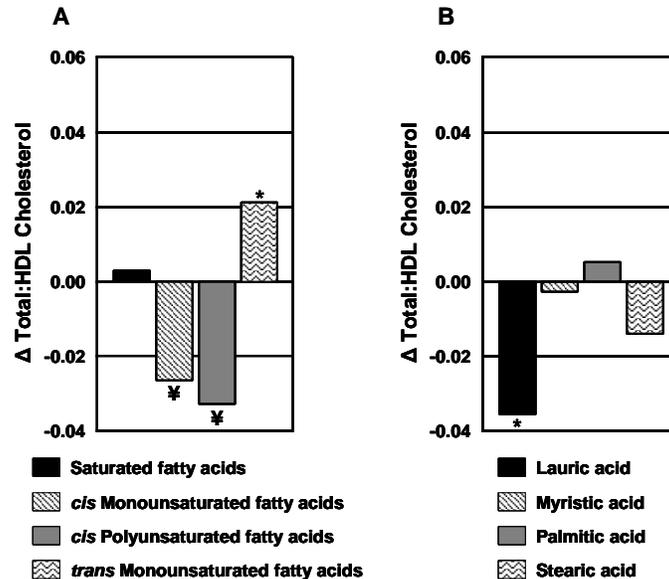
RECENT DEVELOPMENTS IN SATURATED FAT AND MILK FAT

Dietary recommendations by nationally recognized bodies have a substantial impact on the nutrition and health community. The 2010 Dietary Guidelines for Americans recommended restricting the consumption of saturated fat to less than 10 % of total dietary calories (USDA/USDHHS, 2010). In a peer-reviewed publication Hite et al. (2010) challenged this report, including its specific conclusions regarding saturated fat, and pointed out that recommendations were based on science that was inaccurately represented and summarized (as we have discussed in the previous section), and even more serious that the report failed to include the full body of relevant research. Hoenselaar (2012) took this a step further in a peer-reviewed publication by examining recommendations on saturated fat from the report by USDA/USDHHS (2010) as well as reports from two additional important US and European advisory committees – the Institute of Medicine (**IOM**, 2005), and the European Food Safety Authority (**EFSA**, 2010). He summarized the recommendations from these advisory committees as follows:

1. Consume less than 10 % of calories from saturated FA, replacing them with monounsaturated and polyunsaturated FA (USDA/USDHHS, 2010).
2. Keep the intake of saturated FA as low as possible while consuming a nutritionally adequate diet (IOM, 2005).
3. Saturated fat intake should be as low as possible (EFSA, 2010).

These advisory committees cited studies to support their recommendations, but Hoenselaar (2012) pointed out their conclusions were not based on a valid representation of the scientific literature. For example, the effect of saturated fat on LDL-

cholesterol and its connection to an increased CVD risk was cited in all three reports, but concurrent beneficial effects of saturated fat to increase HDL-cholesterol; thereby reducing CVD risk, was systematically ignored. It is unfortunate that due to a focus on the small rise in blood cholesterol with milk consumption, the debate on milk fat has never achieved a reasonable balance in the evaluation of risks and benefits. The overall conclusions by Hoenselaar (2012) were *"Results and conclusions about saturated fat in relation to CVD, from leading advisory committees, do not reflect the available scientific literature"*. Two additional public health advisory committees are the WHO and American Heart Association (**AHA**). Although recommendations by these two bodies were not included in the critiques by Hite et al. (2010) and Hoenselaar (2012), their assessment would also apply to them. The WHO recommends saturated fat intake be reduced to less than 10 % of dietary calories and the 2009 Guidelines by AHA recommends saturated fat be reduced to an even lower < 7 % of total calories (Huth and Park, 2012).

Support for a paradigm shift in conclusions for the relationship between saturated fat, milk fat, and cardiovascular health also comes from recent reviews of the published literature. The comprehensive reviews of Parodi (2009), Givens and Minihane (2011), Kratz et al. (2012), and Huth and Park (2012) reached a similar conclusion – that the majority of observational studies have failed to support an adverse association between the intake of dairy products and CVD, regardless of milk fat levels, and in many cases a long-term beneficial effect was observed.

Several excellent investigations have been reported in the last three years and key studies are summarized in Table 1. de Oliveira Otto et al. (2012) conducted a multi-ethnic study examining the relationship between consumption of saturated dairy fat and CVD; they concluded that *"a higher intake of saturated fat was associated with lower CVD risk"*. Importantly, the authors found that associations between saturated fat and incident of CVD depended on the food source, with the consumption of dairy saturated fat being inversely associated with risk (risk was 0.62 when 5 % of energy was from dairy saturated fat; de Oliveira Otto et al., 2012). These findings raise the possibility that associations of foods that contain saturated fat with health may depend on specific FA present in these foods or the complex mixture of other food constituents, in addition to saturated fat (de Oliveira Otto et al., 2012).

Elwood et al. (2010) conducted a meta-analysis of prospective cohort studies to examine associations between the intake of milk and dairy products and the incidence of ischemic heart disease and stroke. Results indicated *"a reduction in risk in subjects with the highest dairy consumption relative to those with the lowest intake"*; relative risk values were 0.92 for ischemic heart disease and 0.79 for stroke (Figure 4; Elwood et al., 2010). Goldbohm et al. (2011) reported results from a large cohort study designed to examine the association between the intake of dairy products and mortality. Data covered a 10 yr period for 120,852 men and women, and results indicated no association between dairy product consumption and stroke mortality for men or women. Likewise, there was no association between total milk intake and ischemic heart disease mortality in men; whereas a small positive association was observed for women (relative risk = 1.07; Goldbohm et al., 2011). Soedamah-Muthu et al. (2011) conducted a

similar meta-analysis comparing intake of dairy products and the risk of CVD (including coronary heart disease, stroke, and mortality); their meta-analysis gained greater analytical power by including different dairy food categories and different ranges of intake. Results demonstrated that *"milk intake was not associated with total mortality, but may be inversely associated with overall CVD risk"*; relative risk for the later was 0.94 (Soedamah-Muthu et al., 2011).

These findings are in broad agreement with the recently reported outcome of a remarkable 61-yr follow up of the Boyd-Orr cohort. This study involved the recruitment of 4,999 children in England and Scotland in 1937-39 with causes of death recorded from 1948 (van der Pols et al., 2009). Results demonstrated that a family diet in childhood, which was high in dairy products, did not give rise to a greater risk of CVD or stroke mortality. Indeed all-cause mortality was lowest in those with the highest dairy product and milk intake (basic hazard ratio for both, 0.69; 95 % CI, 0.57 to 0.84; P for trend < 0.002). These findings are therefore suggestive that despite milk fat being rich in saturated FA, milk has properties that are beneficial in reducing the risk of CVD.

There are a limited number of studies that report disease rates in subjects who consume natural dairy foods, and in those who consume reduced fat dairy foods. Results from such studies are often confounded however due to the adoption of other health-related behaviors.

Table 1. Summary of recent prospective cohort studies.

Reference	Description/Objective	Conclusion
de Oliveira Otto et al. (2012)	Multi-ethnic study of saturated dairy fat intake and incidence of CVD; 5209 individuals for 10 yr period.	A higher intake of saturated fat from dairy products was associated with lower CVD risk.
Elwood et al. (2010)	Meta-analysis of cohort studies of dairy intake in relation to cardiac health.	Greater intake of milk and dairy products reduced incidence of ischemic heart disease and stroke.
Goldbohm et al. (2011)	Multivariate survival analysis of case cohorts to examine association between dairy product intake and risk of cardiac-related death. Data collected over 10 yr (n=120,853 patients).	Dairy product intake had neutral effects on mortality in men, but in women dairy fat intake was associated with slightly increased mortality from ischemic heart disease.
Soedamah-Muthu et al. (2011)	Dose-response meta-analysis of dairy consumption and incidence of CVD and all-cause mortality.	Milk intake was associated with reduction in overall CVD risk, but no relationship to total mortality.

The appropriate question to ask is: Do fat-reduced milks and dairy foods provide any additional advantage, or does the reduction in fat reduce the benefits of whole milk?

Interestingly, a recent study from Australia reported that full fat (but not low-fat) dairy consumption was inversely associated with cardiovascular mortality and this effect was significant (Bonthuis et al., 2010). Compared with participants in the lowest intake group, participants in the highest full-fat dairy intake group had a multivariable hazard ratio of 0.33 (95 % CI, 0.13–0.81; P for trend = 0.05). Conversely, a meta-analysis of prospective cohort studies by Soedamah-Muthu et al. (2012) suggests that low-fat dairy and milk could contribute to the prevention of hypertension; whereas total dairy intake was not significantly associated with hypertension incidence. Therefore, a statement by German and Dillard (2004) is appropriate: *"Hypotheses [about fat-reduced milks] are the basis of sound scientific debate; however they are not the basis of sound public health policy"*.
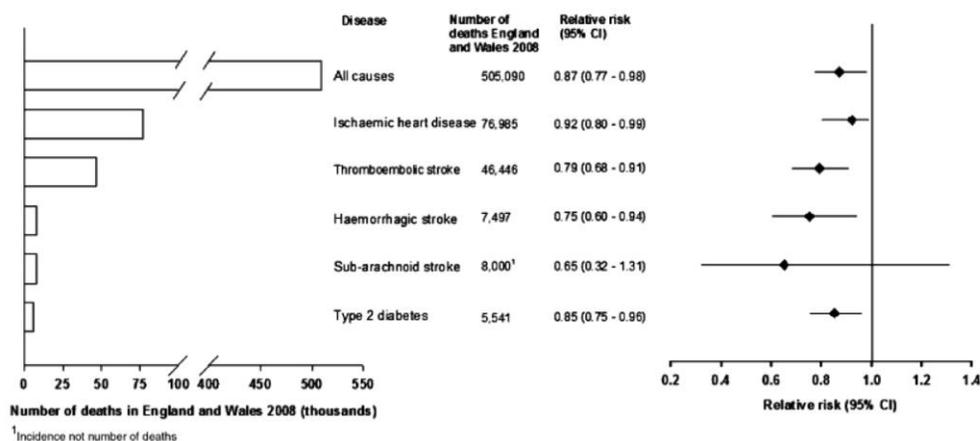
DAIRY PRODUCTS AND HUMAN HEALTH

Consumers are increasingly aware of the connection between diet and health, and scientists are being asked to clarify the role of specific foods in health maintenance and the prevention of chronic diseases. Multidisciplinary studies in developing countries demonstrate that when diets of school children had little or no animal source foods, the intake of essential micronutrients was inadequate resulting in negative health outcomes including severe problems such as poor growth, impaired cognitive performance, neuromuscular deficits, psychiatric disorders, and even death (Nuemann et al., 2002; Randolph et al., 2007). Continued recommendations to reduce milk fat intake may result in inadequate intakes of key nutrients in certain population groups.

Long-term effects of milk and dairy products on health and the prevention of chronic diseases of the general population are also of interest, and these would best be determined in randomized controlled trials. There have been no such trials and realistically none are likely because of the required number of subjects and the long latency period associated with chronic diseases. The best evidence, therefore, comes from prospective cohort studies with disease events or death as the outcome. There have been a number of prospective cohort studies that have evaluated the association between intake of milk and dairy products and the incident of chronic diseases. Results of meta-analysis of such studies provide convincing evidence that milk and dairy products are associated with beneficial effects for long-term health maintenance and the prevention of chronic diseases. The beneficial effects in reducing the risk of CVD were discussed earlier, and additional examples of chronic diseases for which consumption of dairy products reduces risk include: diabetes, obesity, metabolic syndrome, and many types of cancer (Elwood et al., 2008, 2010; Tremblay and Gilbert, 2009; Kliem and Givens, 2011; Grantham et al., 2012; Korhonen, 2012; Kratz et al., 2012). Overall, the science clearly demonstrates the importance of milk and dairy products in childhood development, health maintenance, and the prevention of chronic diseases. Indeed, linking the benefits of milk consumption with deaths from key chronic diseases led Elwood et al. (2008) to conclude that high milk consumers have an *"overall survival advantage"*.

Figure 4. The numbers of deaths in England and Wales in 2008 from various causes and the risks for these causes in subjects with the highest milk/dairy consumption, relative to subjects with the lowest milk/dairy consumption. Adapted from Elwood et al. (2010).

Disease	Number of deaths England and Wales 2008	Relative risk (95% CI)
All causes	505,090	0.87 (0.77 - 0.98)
Ischaemic heart disease	76,985	0.92 (0.80 - 0.99)
Thromboembolic stroke	46,446	0.79 (0.68 - 0.91)
Haemorrhagic stroke	7,497	0.75 (0.60 - 0.94)
Sub-arachnoid stroke	8,000[1]	0.65 (0.32 - 1.31)
Type 2 diabetes	5,541	0.85 (0.75 - 0.96)

Number of deaths in England and Wales 2008 (thousands)

Relative risk (95% CI)

[1] Incidence not number of deaths

SUMMARY

For over a half-century the concept of healthy eating has become synonymous with avoiding fat, especially saturated fat and this remains a centerpiece in nutritional advice of medical societies and government agencies worldwide. Investigations have shown the science behind this advice, however was based on incomplete and in some cases flawed investigations. Nutritional science has advanced rapidly and evidence now demonstrates that the proportion of total energy from fat or saturated fat is largely unrelated to the risk of cardiovascular diseases or other chronic diseases. Indeed there appears to be an enormous disconnect between the evidence from long-term prospective studies and public perceptions of harm from the consumption of milk fat and dairy products. This clearly represents a new paradigm requiring a major shift in recommendations by national advisory groups. Furthermore, milk and dairy products are key components in dietary patterns chosen for optimum health maintenance and the prevention of chronic diseases.

REFERENCES

Bauman, D. E., and J. L. Capper. 2011. Sustainability and dairy production: challenges and opportunities. Proc. Cornell Nutr. Conf. pp. 136-153.

Bauman, D. E., and A. L. Lock. 2006. Animal products and human health: perceptions, opportunities and challenges. Proc. Cornell Nutr. Conf. pp. 45-57.

Bonthuis, M., M.C.B. Hughes, T.I. Ibiebele, A.C. Green, and J.C. van der Pols. 2010. Dairy consumption and patterns of mortality of Australian adults. Eur. J. Clin. Nutr. 64:569–577.

CDC. 2011. Million hearts: strategies to reduce the prevalence of leading cardiovascular disease risk factors – United States 2011. Centers for Disease Control and Prevention, MMWR Report 60:1248-1251.

de Oliveira Otto, M., D. Mozaffarian, D. Kromhout, A. G. Bertoni, C. T. Sibley, D. R. Jacobs Jr., and J. A. Nettleton. 2012. Dietary intake of saturated fat by food source and incident cardiovascular disease: the multi-ethnic study of atherosclerosis. Am. J. Clin. Sci. 96:397-404.

EFSA. 2010. Scientific opinion on dietary reference values for fats, including saturated fatty acids, polyunsaturated fatty acids, monounsaturated fatty acids, trans fatty acids, and cholesterol. Panel on

Dietetic Products, Nutrition, and Allergies. EFSA J. 8:1461. Available at: http://www.efsa.europa.eu/en/efsajournal/pub/1461.htm.

Elwood, P. C., D. I. Givens, A. D. Beswick, A. M. Fehily, J. E. Pickering, and J. Gallacher. 2008. The survival advantage of milk and dairy consumption: an overview of evidence from cohort studies of vascular diseases, diabetes and cancer. J. Am. Coll. Nutr. 27:723S-734S.

Elwood, P. C., J. E. Pickering, D. I. Givens, and J. E. Gallacher. 2010. The consumption of milk and dairy foods and the incidence of vascular disease and diabetes: an overview of the evidence. Lipids 45:925-939.

Ervin, R. B., J. D. Wright, C.-Y. Wang, and J. Kennedy-Stephenson. 2004. Dietary intake of fats and fatty acids for the United States population: 1999-2000. U.S. Department of Health and Human Services, Advanced Data Number 348, November 8, 2004.

Gebauer, S.K., J. Chardigny, M. Jakobsen, B. Lamarche, A.L. Lock, S. Proctor, and D. Baer. 2011. Effects of ruminant *trans* fatty acids on cardiovascular disease and cancer: a comprehensive review of epidemiological, clinical, and mechanistic studies. Adv. Nutr. 2:332–354.

German, J.B., and C.J. Dillard. 2004. Saturated fats: what dietary intake? Am. J. Clin. Nutr. 80:550–559.

Givens, D. I., and A.-M. Minihane. 2009. Dairy products: their role in the diet and effects on cardiovascular disease. *In*: Fatty Acids in Health Promotion and Disease Causation. R. R. Watson, ed. AOCS Publications, Urbana, IL. Pp. 163-180.

Goldbohm, R. A., A. M. Chorus, F. Galindo Garre, L. J. Schouten, and P. A. van den Brandt. 2011. Dairy consumption and 10-y total and cardiovascular mortality; a prospective cohort study in the Netherlands. Am. J. Clin. Nutr. 93:615-627.

Grantham, N. M., D. J. Magliano, A. Hodge, J. Jowett, P. Meikle, and J. E. Shaw. 2012. The association between dairy food intake and the incidence of diabetes in Australia: the Australian Diabetes, Obesity and Lifestyle Study. Public Health Nutrition, Available on CJO 2012 doi:10.1017/S1368980012001310.

Hegsted, D. M., R. B. McGandy, M. L. Myers, and F. J. Stare. 1965. Quantitative effects of dietary fat on serum cholesterol in man. Am. J. Clin. Nutr. 17:281-295.

Hite, A. H., R. D. Feinman, G. E. Guzman, M. Satin, P. A. Schoenfeld, and R. J. Wood. 2010. In the face of contradictory evidence: report of the Dietary Guidelines for Americans Committee. Nutr. 26:915-924.

Hoenselaar, R. 2012. Saturated fat and cardiovascular disease: the discrepancy between the scientific literature and dietary advice. Nutr. 28:118-123.

Huth, P. J., and K. M. Park. 2012. Influence of dairy product and milk fat consumption on cardiovascular disease risk: a review of the evidence. Adv. Nutr. 3:266-285.

IOM. 2005. Dietary fats: total fat and fatty acids in dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids (macronutrients). Institute of Medicine. Available at: http://books.nap.edu/openbook.php?record_id=10490&page=422.

Keys, A. 1953. Atherosclerosis: a problem in newer public health? *In*: Recent Adv. Therapy. Mt. Sinai Hosp. 20:118-139.

Keys, A. 1980. Seven countries: a multivariate analysis of death and coronary heart disease. Harvard University Press, Cambridge, MA.

Kliem, K. E., and D. I. Givens. 2012. Dairy products in the food chain: their impact on health. Ann. Rev. Food Sci. 2:21-36.

Korhonen, H. J. 2012. Production and properties of health-promoting proteins and peptides from bovine colostrum and milk. Cell. Mol. Biol. 58:26-38.

Kratz, M., T. Baars, and S. Guyenet. 2012. The relationship between high-fat dairy consumption and obesity, cardiovascular, and metabolic disease. Eur. J. Nutr. DOI 10.1007/s00394-012-0418-1, published online: 19 July 2012.

Lock, A., and D. Bauman. 2004. Modifying milk fat composition of dairy cows to enhance fatty acids beneficial to human health. Lipids 39:1197–1206.

Lock, A. L., and D. E. Bauman. 2011. Milk fat and human health – separating fats from fiction. Proc. Cornell Nutr. Conf., pp. 126-135.

Maijala, K. 2000. Cow milk and human development and well-being. Livestock Prod. 65:1-18.

Mensink, R. P., P. L. Zock, A. D. M. Kester, and M. B. Katan. 2003. Effects of dietary fatty acids and carbohydrates on the ratio of serum total to HDL cholesterol and on serum lipids and apolipoproteins: a meta-analysis of 60 controlled trials. Am. J. Clin. Nutr. 77:1146-1155.

Neumann, C., D. M. Harris, and L. M. Rogers. 2002. Contribution of animal source foods in improving diet quality and function in children in the developing world. Nutr. Res. 22:193-220.

O'Donnell-Megaro, A. M., D. M. Barbano, and D. E. Bauman. 2011. Survey of fatty acid composition of retail milk in the United States including regional and seasonal variations. J. Dairy Sci. 94:59–65.

Ordovas, J. M. 2005. Diet-heart hypothesis: will diversity bring reconciliation? Am. J. Clin. Nutr. 82:919-920.

Parodi, P. W. 2009. Has the association between saturated fatty acids, serum cholesterol and coronary heart disease been over emphasized? Int. Dairy J. 19:345-361.

Randolph, T. F., E. Schelling, D. Grace, C. F. Nicholson, J. L. Leroy, D. C. Cole, M. W. Demment, A. Omore, J. Zinsstag, and M. Ruel. 2007. Invited review: Role of livestock in human nutrition and health for poverty reduction in developing countries. J. Anim. Sci. 85:2788-2800.

Ravnskov, U. 2002. A hypothesis out-of-date, the diet-heart idea. J. Clin. Epidemiol. 55:1057-1063.

Roger, V. L., A. S. Go, D. M. Lloyd-Jones et al. 2011. Heart disease and stroke statistics—2011 update: a report from the American Heart Association. Circulation 123:e18-209.

Sir-Tarino, P. W., Q. Sun, F. B. Hu, and R. M. Krauss. 2010. Meta-analysis of prospective cohort studies evaluating the association of saturated fat with cardiovascular disease. Am. J. Clin. Nutr. 91:535-546.

Soedamah-Muthu, S. S., E. L. Ding, W. K. Al-Delaimy, F. B. Hu, M. F. Engberink, W. C. Willett, and J. M. Geleijnse. 2011. Milk and dairy consumption and incidence of cardiovascular diseases and all-cause mortality: dose-response meta-analysis of prospective cohort studies. Am. J. Clin. Nutr. 93:158-171.

Soedamah-Muthu, S.S., L.D.M. Verberne, E.L. Ding, M.F. Engberink, and J.M. Geleijnse. 2012. Dairy consumption and incidence of hypertension: a dose-response meta-analysis of prospective cohort studies. Hypertension 60:1131–1137.

Tremblay, A., and J. A. Gilbert. 2009. Milk products, insulin resistance syndrome and type 2 diabetes. J. Am. Coll. Nutr. 28(Suppl. 1):91S-102S.

Ulbricht, T. L. V., and D. A. T. Southgate. 1991. Coronary heart disease: seven dietary factors. Lancet 338:985-992.

USDA/USDHHS. 2010. Dietary Guidelines for Americans 2010. Report of the Dietary Guidelines Advisory Committee, USDA and USDHHS, Washington DC. Available at: http://www.cnpp.usda.gov/DGAs2010-DGACReport.htm.

van der Pols, J. C., D. Gunnell, G. M. Williams, J. M. P. Holly, C. Bain, and R. M. Martin. 2009. Childhood dairy and calcium intake and cardiovascular mortality in adulthood: 65-year follow-up of the Boyd-Orr cohort. Heart 19:1600-1606.

Weinberg, S.L. 2004. The diet-heart hypothesis: a critique. J. Am Coll. Cardiol. 43:731-733.

Willett, W. C. 2012. Dietary fats and coronary heart disease. J. Int. Med. 272:13-24.

Yerushalmy, J., and H. E. Hilleboe. 1957. Fat in diet and mortality from heart disease, a methodoligic note. New York State J. Med. 57:2343-2353.