

Milk: White elixir or white poison?

An examination of the associations between dairy consumption and disease in human subjects



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Implications

- Overall, milk consumption provides health benefits to all age groups.
- Effects of cheese, butter, and fat-reduced and saturated fat-reduced milk and dairy products are less clear and require more research.
- Public health nutrition policy related to milk consumption should be based on the evidence presented and not solely on the believed negative effects of dietary fat.
- Milk is not a white elixir since no study has reported eternal youth from drinking it, but there is certainly no evidence that milk is a white poison!

Key words: cancer, cardiovascular disease, dairy products, milk

Milk in History

Animals were probably first kept for meat, but domestication gave our ancestors access to limited, but continuing supplies of milk. Although the quantity was probably small, it is likely that milk was a more sustained supply of nutrition than meat, and so animals were selectively bred from earliest times. From the study of food residues on pottery fragments found in Turkey, it seems that animals may have been milked as early as the seventh millennium BC, and evidence from other sources indicates that a wide range of animals were kept for their milk, including sheep, goats, cows, water buffalo, reindeer, camels, horses, and even asses.

The fact that milk and dairy products have made an important contribution to the diet of humans throughout history is somewhat surprising. Most mammals stop drinking milk soon after weaning, and humans are the only species that consumes milk throughout life. In mammals generally, and in some human races, the gene for the enzyme lactase gets switched off in most individuals, and thus the ability to digest lactose

is lost, severely limiting the quantity of milk that can be consumed. In Northern Europeans, however, the gene remains active in most people and well over 90% can digest lactose throughout life and consequently consume relatively high quantities of milk (Sahi, 1994).

There are marked racial differences in the consumption of milk, and in 1965, it was suggested that these were attributable to racial differences in the prevalence of lactose malabsorption (Cuatrecasas et al., 1965). A “geographic hypothesis” was proposed, based on random genetic drift or some other process of selection independent of dairying, which led certain communities to take up dairying and the use of milk as food. The “aberrant” persons would then enjoy a significant selective advantage (Simons, 1978). In addition to a survival advantage, it was suggested that lactose absorbers may also have experienced a small breeding advantage.

Support for all this was recently obtained in an archaeological dig. DNA was obtained from bone samples belonging to a small number of Neolithic subjects dated to around 5,500 BC. The mutation in the lactase gene was found to be absent, suggesting that the ability to digest lactose and hence to consume unlimited quantities of milk, probably developed within the past 7,000 years (Burger et al., 2007). The high prevalence of the mutation within Northern European communities is consistent with it having conferred a considerable survival advantage. Curry (2013) suggests that the availability of a new source of nutrition may have been a prime factor in allowing bands of farmers and herders to displace the hunter-gatherers already resident throughout Europe.

With urban growth, the time between milking and consumption of the milk became longer, and transport became a serious problem. Milk is an excellent medium for microbial growth, and milk consumption became associated with a range of diseases, including scarlet fever, cholera, typhoid, and salmonella. A chronic disease throughout the community was tuberculosis, both human and bovine, and a report in 1943 estimated that between 5 and 10% of farms in England were marketing milk containing *Tubercle bacilli*, 20 to 40% with *Brucella abortus*, and a much greater proportion with *Haemophilus streptocci*. The report noted that between the years 1912 and 1937, about 65,000 people died of tuberculosis contracted from milk, and 400 to 500 people each year experienced “undulant fever,” as brucellosis was then called (Wilson, 1943).

The pasteurization of milk represented a major advance, and although the widespread adoption took many years, much is owed to Louis Pasteur (1922–1985), who not only introduced the heating of milk and other foods as a way of preserving them, but his work provided direct support for the germ theory of disease and helped towards improvements in clinical practice. Pasteurization has now led to milk being widely consumed across the world, being considered one of the safest foods (Hotchkiss, 2001). The distribution of milk was facilitated by the development in 1884 of “The Thatcher Common Sense Milk Jar,” a glass bottle sealed with a waxed paper disc and later, in 1932, by plastic-coated paper milk cartons, and more recently by the Tetra-Pak, launched in 1951.

Recent controversy about milk has been intense, as a search of the internet will quickly show. One headline reads: “White Poison: The Horrors of Milk,” and contains statements about “the pus, blood, antibiotics, and carcinogens in milk” and “the chronic fatigue, anemia, asthma, and autoimmune disorders” caused by milk consumption. On the other hand, equally accessible on the web, is an article associating milk with the “elixir of life,” a term implying the conferring of eternal youth. How are we to decide between such extreme opinions? After all, an adequate evaluation of this last claim would necessitate a randomized controlled trial in which the outcome measured is eternal youth!

The gold standard in research on any health issue is the randomized controlled trial. While limited randomized trials have been conducted in infants and in children, using outcomes such as growth, or muscle mass, no adequate randomized trial to evaluate milk and total health or survival has been reported, and none is ever likely to be conducted. The numbers of subjects, the compliance required, and the duration of the trial would be totally unacceptable—and unfundable! The best evidence on associations between milk and dairy consumption, and health and survival, comes therefore from cohort studies, and much of what follows in this review is based on prospective cohort and case-control studies of milk and dairy consumption as predictors of chronic diseases and of death. This is based on careful searches of the published literature to identify every relevant study, followed by “overviews” and “meta-analyses” of all of the results from all of the relevant studies. Epidemiological studies are long term, and therefore the data that we have summarized and the conclusion we have drawn relate overwhelmingly to whole milk and full-fat dairy items.

Milk and Children

Milk and growth

In 1926, a report by the UK Medical Research Council showed that giving of an extra pint (568 mL) of milk to boys in a home for children led to a marked increase in growth (Corry Mann, 1926). British nutrition policy encouraged milk drinking for children. The UK Education Act of 1944 established the provision of one-third of a pint (190 mL) of milk every school day for all children under the age of 18. In 1968, this provision was withdrawn for secondary school children (ages 11 to 18 years), and in 1971, it was withdrawn for children over 7 years old.

An opportunity was taken in 1982 to conduct a randomized trial to evaluate school milk and child growth (Baker et al., 1980). Almost 600 schoolchildren aged 7 and 8 years in families with four or more children were chosen from selected schools in areas with high socioeconomic deprivation in South Wales, UK. A background survey of 3,337 children in schools throughout the whole area was also conducted to give data on the degree of deprivation and possible under-nutrition of the children selected

for the trial. This showed that the selected children were on average 2.5 cm shorter and 1.5 kg lighter than the average for the area, and for height, they were representative of the lowest 20% of children throughout the whole county. The trial involved the provision of 190 mL of milk every school day. At the end of two school years, the children provided with milk were taller by 0.28 cm and heavier by 0.13 kg than those randomized to the control group. Furthermore, there was a clear and significant positive gradient in the increase in growth from the children in families in the highest social classes to those in the lowest.

The value of milk to children is now widely recognized, and in 2000, the Food and Agriculture Organization of the United Nations declared a World School Milk Day. The goal was to focus attention on milk by encouraging its use by children to establish the inclusion of milk in a healthy lifestyle throughout life. Thirty-four countries now celebrate World School Milk Day each year.

Milk and minerals

Special concern focuses on the mineral intakes of children. About 70% of bone weight is accounted for by calcium phosphate, and thus adequate dietary calcium supply is essential to permit optimal bone growth. A sub-optimal calcium intake reduces bone density more quickly than it affects growth (Moore et al., 1963), and radiographic evidence of rickets has been found in children with a low calcium intake, despite adequate vitamin D status (Root, 1990). A 2-year milk intervention study with 757 Chinese girls initially aged 10 years compared those who consumed 330 mL of calcium-fortified milk on school days with those who additionally had a vitamin D supplement and a control group that had neither. The consumption of the milk, with or without added vitamin D, gave rise to a significantly greater rate of height increase, body weight, total bone mineral mass, and bone mineral density. Over the intervention period, mean calcium intake was 649, 661, and 457 mg·day⁻¹ for the milk, milk plus vitamin D, and control groups, respectively (Du et al., 2004).

These findings are of concern to the situation in the UK. Table 1 shows the results for calcium intake obtained by the most recent National Diet and Nutrition Survey (Bates et al., 2012). The Reference Nutrient Intake (RNI) for calcium increases markedly after the age of about 10 years, and it is clear and concerning that a substantial proportion of children, girls in particular, do not meet the RNI. Milk and dairy products are rich sources of dietary calcium, and across the population in the UK as a whole, these foods provide about 60% of the RNI for calcium (Kliem and Givens, 2011).

A marked fall in milk consumption is no doubt a key contributor to the observed suboptimal calcium intake by many children, and a suboptimal calcium intake may well extend beyond childhood. A recent two-year pro-

Table 1. The global-average water footprint of crop and animal products*

Age (years)	Calcium		Magnesium		Mean milk intake (mL/d)
	RNI (mg/d)	Mean intake (% RNI)	RNI (mg/d)	Mean intake (% RNI)	
4 to 10	500	161	160	124	200
11 to 18 male	1000	87	290	79	156
11 to 18 female	800	85	290	64	110
19 to 64 male	700	129	300	96	152
19 to 64 female	700	104	270	84	124

* Source: Mekonnen and Hoekstra (2010). Reprinted with permission of the authors.

spective cohort study aimed to identify nutrients, foods, and dietary patterns associated with stress fracture risk and changes in bone density in 125 female competitive distance runners aged 18 to 26 (Nieves et al., 2010). The results showed that 17 subjects had at least one stress fracture during the follow-up period and that greater intakes of calcium, skimmed milk, and dairy products were associated with reduced rates of stress fracture. Each additional cup of skimmed milk drunk per day was associated with a 62% reduction in stress fracture incidence and a dietary pattern of high dairy products and low fat intake was associated with a 68% reduction as well as increased bone mineral density.

A recent study in the USA indicated that except for children and adolescents with very low calcium intakes, magnesium intake may be more important in relation to bone development (Abrams et al., 2014). The study was based on 63 healthy children aged 4 to 8 years, none of whom were taking vitamin or mineral supplements. The results showed that although calcium intake was not significantly associated with total bone mineral content or density, intake of magnesium and the amount absorbed were key predictors of bone mass. The extent to which these results can be extrapolated to the general population is of course uncertain, but milk and dairy products are important sources of magnesium and are especially important during the phase of rapid bone growth in adolescence. Table 1 shows that children in the UK have a marked suboptimal magnesium intake in addition to that of calcium. This is a substantial concern.

Milk in Adulthood

Milk consumption and body weight

The burden of overweight is increasing rapidly worldwide (Kopelman, 2000), and obesity, usually defined as a body mass index (BMI) of 30 mg·day⁻¹ or more, is recognized as an increasingly important risk factor for chronic diseases, including diabetes, cardiovascular disease, and cancer. The relationship between body weight and diabetes is particularly striking,

with overweight and obesity alone accounting for about 70% of type 2 diabetes (Hu et al., 2001). Having examined this relationship in a sample of 121,000 nurses in the USA, Hu et al. (2001) stated that

“...the majority of cases of type 2 diabetes could be prevented by weight loss.”

A large body of evidence from observational, cross-sectional, and prospective studies is consistent with a negative association between dairy consumption and both body weight and central obesity (Dougkas et al., 2011). For example, a cross-sectional study showed dairy consumption to be inversely associated with central obesity, with odds ratio of 0.56 (95% confidence interval, CI: 0.37 to 0.84; Pereira et al., 2013). In addition, longitudinal data from the Framingham Heart Study confirmed this association. Subjects with a daily consumption of three or more portions of dairy foods had, over a 17-year period, 50% less weight gain and 20% less increase in waist circumference, than subjects with an intake of dairy foods of one or less serving per day (Wang et al., 2013). A systematic review of prospective studies gave further confirmation of a protective effect of dairy consumption on obesity, with all but one of nine studies showing a beneficial association between dairy consumption and body weight (Louie et al., 2011).

Many randomized trials have evaluated the association between dairy consumption and body weight and fat mass, but most of these have been small and short term, and while some have included energy restriction, others have aimed simply at weight maintenance. The results overall are therefore difficult to interpret. Nevertheless, a meta-analysis of 29 randomized trials with varied designs indicated that while the inclusion of dairy foods into weight maintenance diets is not associated with weight loss or weight gain, there were weight loss benefits from the combination of these foods and energy-restricted diets (Chen et al., 2012).

Milk consumption and blood cholesterol

The medical literature includes at least 10 hypotheses that attempt to support the belief that harm results from milk consumption (Elwood, 2001). These refer to a rise in plasma homocysteine, a high calcium intake, and phytoestrogens, but the most frequent is undoubtedly a rise in plasma cholesterol concentration consequent on the ingestion of milk or dairy foods. Perhaps the most unusual hypothesis is that subjects who drink a lot of milk may be denying themselves the cardiovascular protection afforded by alcohol (Popham et al., 1983)!

Milk and dairy products are an important source of saturated fatty acids (SFA), which raise total blood cholesterol and low-density lipoprotein cholesterol (NCEP, 2002). Nevertheless, a growing body of recent literature fails to show a hypercholesterolaemic effect of dairy products (Huth and Park, 2012) and other studies have shown that SFA typical of those in milk fat also increase high-density lipoprotein cholesterol, which is protective (Mensink et al., 2003).

Although dietary recommendations for the prevention of cardiovascular disease have suggested reducing high-fat dairy consumption to lower SFA consumption to <10% of energy intake (EUFIC, 2009), evidence on the effect of dairy consumption on lipid and apolipoprotein concentrations is still ambiguous due to the relatively limited number of studies (Corella and Ordovas, 2012). Comprehensive reviews of intervention trials concluded that whole-fat milk raises blood lipid concentrations significantly more than low-fat milk, and butter significantly more than cheese (Huth and Park, 2012), and that milk fat with reduced SFA is likely to lead to reduced plasma low-density lipoprotein cholesterol concentrations (Livingstone et al., 2012). Dairy products normally contain *trans* fatty acids at reduced concentrations although these are of different isomeric profile to those in industrially hydrogenated fats. The number of studies is limited, and current evidence suggests they pose no threat to health (Bendsen et al., 2011);



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Milk is valuable for all ages.

indeed, some may reduce chronic disease risk. Notably *trans*-palmitoleic acid has been shown to be associated with a reduced risk of diabetes (Mozaffarian et al., 2010).

However, given the limited data on the effect of whole milk and dairy products on lipid profile as a risk marker of cardiovascular disease, firm conclusions cannot be drawn, and further research on milk components and dairy as whole foods on lipid profile is needed. Dairy foods contain many nutrients and bioactive compounds, which may be protective to the development of vascular and other diseases. The only valid basis for conclusions comes from long-term studies of the consumption of milk and dairy foods and the incidence of disease or death.

Milk consumption, blood pressure, and arterial stiffness

Hypertension is one of the leading risk factors in the development of heart disease and stroke and is estimated to be responsible for around 13% of all deaths worldwide (Alwan, 2011). There is abundant evidence of a protective effect of the consumption of milk and dairy produce on blood pressure (Griffith et al., 1999; Livingstone et al., 2013). Of particular interest is the Dietary Approaches to Stop Hypertension (**DASH**) trial (Appel et al., 1997), which tested a diet high in fruit and vegetables and low-fat dairy products and showed reductions in the systolic and diastolic pressures of subjects. In hypertensive subjects, the reductions were 11 to 12 mm of Hg and 6 to 7 mm of Hg, representing about 44 and 35% of the standard deviation of systolic and diastolic pressures, respectively. Moreover, a recent meta-analysis of prospective cohort data by Soedamah-Muthu et al. (2012a) confirmed these relationships by demonstrating a significantly reduced relative risk (**RR**) for hypertension ($RR = 0.97$) following moderate intakes of total dairy.

In addition to the impact on blood pressure, the effect of these foods on other, more novel markers of vascular health is becoming increasingly relevant. The health of the walls of the blood vessels is a key determinant of vascular disease. Any loss in elasticity is a major factor in blood pressure, and the development of “hardening” or atherosclerosis contributes to intra-arterial thrombosis, occlusion, and consequent infarction. Therefore, methods to measure the health of the arterial system as a whole and that of arterial walls in particular are becoming increasingly used in clinical settings, and this has increased our understanding of vascular health and disease. Measures of arterial stiffness include arterial pulse wave velocity and augmentation index, both of which are predictive of heart attacks and stroke (Boutouyrie et al., 2002) and all-cause mortality (Janner et al., 2012). Whereas pulse wave velocity measures the speed of propagation along the artery, augmentation index is calculated from the blood pressure wave form and is based on the degree of wave reflection.

Both cross-sectional (Crichton et al., 2012) and longitudinal (Livingstone et al., 2013) cohort studies have shown significant relationships between dairy product intake and arterial pulse wave velocity. Data from the Caerphilly Prospective Study, based on 2,512 men followed for a mean of 28 years, showed a significant inverse relationship between dairy product intake and augmentation index: subjects in the highest quartile of dairy product intake (mean 480 g·d⁻¹) had 2% ($P = 0.02$) lower augmentation index compared with subjects with the lowest dairy intake (mean 154 g·d⁻¹; Livingstone et al., 2013). A number of intervention studies have also been conducted to investigate milk proteins and their peptides in relation to vascular function. Studies are limited in number but suggest benefit both by reducing blood pressure and lowering augmentation index (Pal and Ellis, 2010).

The mechanisms by which milk and dairy products are cardio-protective have not been fully elucidated. Importantly, milk is a complex food, containing a variety of biologically active components that may affect blood pressure. Intakes of calcium, potassium, and magnesium have shown beneficial relationships, but the most thoroughly investigated to date are milk proteins and their peptides. During digestion, milk proteins are degraded into bioactive peptides, some of which appear to inhibit angiotensin converting enzyme, a key enzyme in the function of the renin-angiotensin system. A recent meta-analysis of trials on milk peptides reported small, but significant reductions in blood pressure (Fekete et al., unpublished).

Milk consumption and cardiovascular disease

The renowned medical epidemiologist, Archie Cochrane, was one of the first to urge that conclusions in clinical practice and in medical research are evidence based and that the evidence comes from “all the available, bias-free relevant studies” (Cochrane, 1972). More recently, Alvarez-Leon et al. (2006) pointed out that statements about the benefits and risks of dairy product consumption appear to be based on selected physio-pathological data, such as relationships with blood cholesterol level, and not on valid epidemiological evidence, commenting that “public health nutrition should not be unaware of the need for evidence-based conclusions.”

For the reasons noted earlier, the best evidence on dairy food consumption, health, and survival, comes therefore from long-term cohort studies with disease events and death as the outcomes, and the most reliable conclusions are those that are derived from overviews and meta-analyses of all of the bias-free, long-term cohort studies. There have been a number of overviews published on the relationship between consumption of milk and dairy foods and cardiovascular disease. To date, the largest was based on 38 cohort studies (Elwood et al., 2010), and what follows is largely based on that report, although the meta-analyses have all been updated by the addition of data from six recently published studies (Bonthuis et al., 2010; Goldbohm et al., 2011; Sonnestedt et al., 2011; Avalos et al., 2012; Soedamah-Muthu et al., 2012b; van Aerde et al., 2013). Table 2 gives the outcome of this meta-analysis relevant to a disease outcome together with a few details on each.

Twenty-two reports have examined the consumption of milk/dairy produce and incident ischaemic heart disease although only 17 were judged acceptable for inclusion in an overview and meta-analysis. Together, these comprised a total of 4.5 million person-years, during which 21,571 heart disease events or deaths attributed to heart disease occurred. Within each study, an estimate of the **RR** of cardiovascular disease was made within a group of subjects with the highest milk/dairy consumption compared with a group of subjects with the lowest consumption. Most often, these groups were the fifth of subjects with the highest milk/dairy consumption, and the fifth with the lowest consumption. Within each study, there were attempts made to allow for possible confounding by a variety of personal, social, and biological factors.

For heart disease, the overall **RR** was 0.92, suggesting a reduction of about 8% in those subjects who had reported the highest milk/dairy intake compared with the fifth of subjects with the lowest intake (combined **RR** of 0.92; 95% CI, 0.86 to 0.99). The degree of confidence that can be put on this estimate is indicated by the CI figures. These figures indicate the range of estimates within which there is a 95% chance that the true reduction exists. That is, while the effect of high milk/dairy consumption is associated with an 8% reduction in heart disease, one can be reasonably certain that the true reduction lies within the range of a 14% reduction and a 1% reduction. The lack of significant heterogeneity indicated in the table implies that there is a fair degree of consistency between the various studies. Since we are aiming

Table 2. Milk and dairy consumption in cohort studies and new disease events (based on Elwood et al., 2010 with updates, see text).

Disease outcome	Number of cohorts (acceptable studies)	Total number of 'person years'	Number of incident disease events	Estimate of combined adjusted relative risk* (95 % CI) (<i>P</i> for heterogeneity†)
Ischaemic heart disease	22 (17)	4.5 million	21,571	0.92 (0.86, 0.99) Heterogeneity <i>P</i> = 0.765
All strokes	12	8.5 million	10,567	0.81 (0.71, 0.92) Heterogeneity <i>P</i> = 0.001
- haemorrhagic stroke	5	0.36 million	5,946	0.75 (0.60, 0.94) Heterogeneity <i>P</i> = 0.014
- subarachnoid bleed	3	0.96 million	484	0.93 (0.84, 1.02) Heterogeneity <i>P</i> = 0.004
Diabetes	7	1.7 million	7,779	0.85 (0.75, 0.96) Heterogeneity <i>P</i> = 0.023
All-cause mortality	12 (9)	0.76 million	21,382	0.91 (0.78, 1.05) Heterogeneity <i>P</i> = 0.070

* Relative risk refers to the risk of developing a disease in the fifth of subjects with the highest consumption, relative to the fifth of subjects with the lowest consumption. 95 % CI gives the 95 % confidence interval around the relative risk. Thus relative risks with a higher confidence limit less than 1 indicate that the high consumers have a significantly lower risk than the low consumers.

† Heterogeneity is the outcome of a test to determine if the effects found in the individual studies are similar enough to allow a combined estimate to be derived that will be a meaningful description of all the studies. Statistically significant heterogeneity is indicated when *P* < 0.05.

to use meta-analysis to estimate the combined effect of a set of similar studies, it is important to check that the effects found in the individual studies are similar enough (i.e., lack heterogeneity) to allow a combined estimate to be derived that will be a meaningful description of all the studies.

Stroke is of particular interest because of the clinically important reduction in blood pressure, which has been repeatedly shown to be associated with a high intake of dairy foods. Blood pressure is an important factor in three rather different clinical events. The most common cerebral event is an ischaemic stroke, and this is due to a clot or an embolus blocking a blood vessel. Haemorrhagic stroke is much less common and is caused by bleeding into the brain. The rarest cerebral lesion is a subarachnoid bleed in which a bleed occurs from a vessel within the skull, but outside the brain substance. A raised blood pressure is important in each of these, and the risks of all three appear to be reduced by high milk and dairy food consumption. It is likely that the reductions in risk are mediated by reductions in blood pressure, but other mechanisms may well be involved.

Twelve studies reported on 10,567 stroke events, most of which were ischaemic, within a total of 8.5 million person-years. The RR (0.81; 95% CI, 0.71 to 0.92) indicates a probable reduction of 19% in subjects with a high milk/dairy intake, but possibly a reduction of up to 29%, or maybe a reduction of only around 8%. Five studies included data on haemorrhagic strokes, 5,946 such events having occurred in 360,000 person-years, and the RR (0.75; 95% CI, 0.60 to 0.94) implies a reduction of 25%, with CI limits of 40 and 6%. Almost 500 subarachnoid bleeds were reported in three studies within just under a million person-years, and the RR (0.93; 95% CI, 0.84 to 1.02) suggests a possible small reduction in the highest dairy consumers. It has to be noted that the significant estimates of heterogeneity indicated for stroke in Table 2 imply that there are significant inconsistencies between the various studies, which may have influenced the conclusions drawn.

The other major disease of interest in relation to milk and dairy consumption is diabetes. In this condition, there are few suggestions as to possible mechanisms of relevance, but the finding by Mozaffarian et al. (2010) of a substantial negative relationship between one of the fatty acids present in whole milk (*trans*-palmitoleic acid) and diabetes indicates a possible mechanism. This evidence is supported by the present overview, based on seven cohorts with a total of 7,779 new cases of diabetes during 1.7 million person-years of follow-up. These yield a 15% overall reduction in diabetes (RR 0.85; 95% CI, 0.75 to 0.96) associated with a high milk/dairy intake, with confidence limits of 25 and 4%. Again,

there is evidence of some heterogeneity between the individual studies in the meta-analysis.

A number of overviews by other authors have been published. Gibson et al. (2009) identified 12 cohort studies and stated that there are “no consistent findings to support the concept that dairy food consumption is associated with a greater risk of coronary heart disease.” Mente et al. (2009) looked at five cohort studies and reported that milk has “no significant association with coronary heart disease” (their estimate of the RR was 0.91; 95% CI, 0.73 to 1.00). Soedamah-Muthu et al. (2012b) examined cardiovascular mortality and all-cause mortality in 17 prospective studies and judged that while milk consumption was not associated with all-cause mortality, it may be associated with a reduction in overall cardiovascular risk.

It may be reasonably concluded that evidence relating to milk and dairy produce cannot be applied to butter, being almost pure milk fat, and probably not to cheese, which is also relatively fat rich. A difficulty is, however, that while the milk consumed by different subjects is relatively easily estimated quantitatively, the estimation of butter consumption is almost impossible. Nevertheless, in five studies estimates of butter intake were made, usually in very crude terms. Only three of these gave sufficient data to enable inclusion in a meta-analysis. The results are homogeneous, but the overall relationship between butter consumption and vascular events (RR 0.93; 95% CI, 0.84 to 1.02) is not statistically significant. In another early cohort study (Gillman et al., 1997), 832 men were followed for 21 years during which there were 267 incident coronary heart disease (CHD) events. No original data are given in the report, but the authors commented “butter intake did not predict CHD incidence.”

Evidence on cheese consumption and vascular disease is also limited. Results have been reported from six cohort studies, but sufficient data for a meta-analysis are given in only two. However, there is a massive difference in the numbers of events and hence in the power of the two studies with conclusions being based on only 64 vascular events in one and on 2,702 disease events in the other. When allowance is made for this by weighting the studies appropriately, the estimate of RR from cheese is 0.90 (95% CI, 0.79 to 1.03).

Overall, it seems reasonable to conclude that there is no evidence that dairy foods as a total group are associated with harm to health either in terms of heart disease, stroke, or diabetes, and indeed, milk in particular is probably beneficial in relation to these disease outcomes. There is, however, an urgent need for more data on the differential effects of dairy products, perhaps in particular for cheese, butter, and fat-reduced milk.

Dairy Food Consumption and Cancer

Relationships between dairy food and cancer were examined in detail by the World Cancer Research Fund and the American Institute for Cancer Research (WCRF, 2007). Their report stated that milk consumption probably protects against colorectal cancer (RR 0.78; 95% CI, 0.69 to 0.88) and possibly bladder cancer (RR 0.82; 95% CI, 0.67 to 0.99) but is associated with a possible increase in prostate cancer (RR 1.05; 95% CI, 0.98 to 1.14). A more recent meta-analysis (Aune et al., 2012) based on a total of 19 cohort studies examined these relationships in 12 cohort studies containing just over one million subjects, of which 11,579 developed colon cancer. The results showed that milk and total (i.e., all types) dairy products, but not cheese or other dairy products (mainly butter, yogurt, ice cream, and fermented milk), are associated with a reduction in colorectal cancer risk. The summary RR were 0.83 (95% CI, 0.78 to 0.88) per 400 g·d⁻¹ of total dairy products and 0.91 (95% CI, 0.85 to 0.94) per 200 g·d⁻¹ of milk intake.

These relationships with cancer are poorly understood at present though a beneficial effect on colon cancer risk has also been reported with calcium supplements, and surprisingly, a synergistic effect between calcium and low-dose aspirin prophylaxis has been described in two randomized studies (Grau et al., 2005).

Limitations on Use of Cohort Studies

The results of cohort studies, such as presented here, while providing extremely valuable data, do have inherent limitations. There are differences in social class, smoking, and other factors between subjects who drink milk and those who drink little or none. Some of the studies comment on these (Shaper et al., 1991; Elwood et al., 2010), and while all of the estimates on which we have based our overall meta-analyses have each been adjusted for a number of confounding factors (age, social class, smoking, alcohol, and activity), some residual confounding by unknown factors is still likely. Although milk consumption can probably be estimated fairly well, the estimation of total dairy is more difficult, and the estimation of butter intake is almost impossible. It is also possible, but highly unlikely, that publication bias has led to studies that showed harm from dairy consumption being preferentially withheld from publication.

Fat-Reduced Dairy Products

In recent years, fat-reduced milk has become enormously popular throughout the developed world. Introduced around 1989 in the USA and around 2000 in the UK on the assumption that it is “healthier” than whole milk, valid evidence to support this has never been provided. In fact, attempts to use prospective studies to evaluate different kinds of milk raise a serious difficulty, namely confounding. Confounding refers to the effects on a relationship of interest of factors that have no direct relevance. Thus, people who adopt a behavior that they believe is beneficial to health, like drinking fat-reduced milk, are likely to adopt other behaviors likely to be beneficial such as regular exercise. This makes it virtually impossible to know how much benefit, if indeed there is benefit, is attributable to the reduction of milk fat and how much is attributable to other healthy behaviors.

In fact, the appropriate question to be asked in relation to fat-reduced dairy foods is whether they lead to an increase, or a reduction, in the benefits conferred by whole milk. In fact, it is very reasonable to ask whether or not the removal of milk fat is indeed harmful. As noted above, the study of Mo-



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zaffarian et al. (2010) reported an association between one of the fatty acids present in whole milk (*trans*-palmitoleic acid; *t*-9 16:1) and a “substantial” reduction in diabetes. Unfortunately, the issue of fat reduction of milk and dairy items simply cannot be settled with any reasonable degree of certainty on the evidence available at present. In the absence of evidence from large, long-term randomized trials, the statement of German and Dillard (2004) is therefore most apposite: “such hypotheses (about fat-reduced milks) are the basis of sound scientific debate; however, they are not the basis of sound public health policy.” This is, however, an area requiring critical study.

Conclusions

Overall, it can reasonably be concluded, with a considerable degree of confidence, from a systematic review of all the data from all the available studies, that milk consumption carries no risk to health but is associated with worthwhile increases in child growth, reductions in blood pressure, no increase in body weight (in isoenergetic diets) and important reductions in the risks of vascular disease, diabetes, and colorectal cancer. The effects of cheese and butter are less certain, as is the value of fat-reduced and SFA-reduced milk and dairy products. Research is urgently needed in these areas. The bottom line, therefore, is that while milk consumption is undoubtedly beneficial to health, it is not a white elixir, in that that no study has reported eternal youth from milk drinking! But there is certainly no evidence that milk is a white poison!

Literature Cited

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Wilson, G.S. 1943. The pasteurization of milk. *BMJ* 1(4286):261–262. Table 1. Reference nutrient intakes (RNI) and intake as % of RNI for calcium and magnesium together with average milk intakes for children and adults in the UK (from Bates et al., 2012)

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