Section 4

Health

Chapter 16

Motivational mismatch: evolved motives as the source of—and solution to—global public health problems

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Introduction: evolutionary public health

While public health in most countries of the world is better now than it has ever been, a huge burden of preventable disease still remains. Solutions exist: we know that people at risk of HIV infection should use condoms, children in malaria-rife countries should sleep under bednets, we should wash our hands with soap, and that we should exercise more and eat a better diet. However, our behaviour does not seem to match our knowledge. While we mostly *know* what is good for us, the problem is that we do not seem to want to *do* it. This disjuncture between what is desirable and what is health-promoting is the source of many of today's most pressing public health problems.

From an evolutionary perspective this provides something of a puzzle. Humans have exquisitely complex brains that evolved to drive adaptive behaviour—behaviour that aided the survival and reproduction of our ancestors. These brains should be making us behave in ways that are healthy, not unhealthy. Of course, for the most part, they do. Our fear centres keep us away from predators and cliff edges, our disgust system keeps us away from parasite-ridden food and bodily wastes, our hunger motive keeps us seeking the nutrients we need, and our nurture system drives us to protect and care for our children. However, there are still many ways in which we harm our own health.

Evolutionary theory has much to contribute to public health and medicine. It helps us to understand the arms race between pathogens and hosts (e.g. HIV, malaria), the trade-offs between health and other fitness benefits (e.g. birth trauma versus infant cranial size), the functioning of our defence systems (e.g. fever and nausea), and the reasons for the diseases of aging, for example (Nesse and Williams 1995). Research in such areas is increasingly bearing fruit (Nesse et al. 2010). The proponents of Darwinian medicine have also pointed to the fact that there are major differences between our modern environments and those in which we evolved, which lead to what have been termed the 'diseases of civilization'—for example, modern diets causing obesity and excessive cleanliness causing allergies (Eaton et al. 1988; Nesse and Berridge 1997). This is called the 'mismatch' hypothesis, because it emphasizes that physiological and psychological characteristics which were adaptive in ancestral environments may be less favourable to survival and reproduction in current settings (Nesse 2004; Gluckman and Hanson 2006).

In this chapter we focus on the psychological mismatch between the environments in which we evolved and in which we now live. We show that most current public health problems can be explained by maladaptive behaviour in the context of massive environmental changes, most having occurred since the Industrial Revolution 150 years ago. We show how almost all of our major

public health problems are associated with motivated behaviour, usually because we over- or under- use evolutionarily novel technologies. Hence, while we can trace suboptimal health to a lack of fit between our evolved motives and our current environment, understanding of these motivational drivers can help us to modify behaviour, environments, and technologies such that they generate healthier outcomes. We give an example of how ancient motives can be harnessed for the benefit of public health in the case of handwashing with soap—a novel health protective technology for which take-up is suboptimal. In short, we argue that, even if our ancestral motivations help to create public health problems, they can also help to solve them, once we understand how they work.

Public health: what's the problem?

Public health is better today than it ever has been. Infant mortality has been falling in nearly every country in the world[1] and there is no end in sight to improvements in longevity (Oeppen and Vaupel 2002). Yet we still die of avoidable causes. Today's big public health problems come in two varieties. First, a large proportion of the world still lives below the poverty line of one dollar per day and in circumstances of low public investment in healthy environments. Lacking in resources with which to grow or purchase food, with poor access to water and sanitation, and with no option but to burn solid fuels, people are prey to the deficiencies and diseases of poverty. In developing and resource-poor settings, infectious diseases are the major cause of premature mortality (65% of Africans die from infection compared to 35% of South Asians and 5% of those in Europe and the US.[2] Second, in contrast, people living in countries that have undergone the demographic transition (and increasingly, some population segments in developing countries) suffer primarily from diseases of affluence. People live longer and die of chronic, rather than infectious, causes, including cardiovascular disease, cancer, and diabetes (World Health Organization 2009).

Ezzati et al. (2002) comprehensively assessed the factors that could be modified to improve public health in high-, medium-, and low-mortality countries. Figure 16.1 shows their top 20 causes of loss of disability-adjusted life years (DALYs) globally. Top of the list came childhood and maternal underweight (associated with 9.5% of total DALYs lost), high blood pressure (4.4%), and alcohol (4.0%). However, as Figure 16.1 shows, there were major differences by region. For example, in developed regions the most important contributors to the burden of disease were tobacco (12.2%), high blood pressure (10.9%), alcohol (9.2%), high cholesterol (7.6%), and overweight (7.4%). In the high-mortality countries, which include sub-Saharan Africa and South East Asia, the leading causes of burden of disease included childhood and maternal undernutrition (14.9%), micronutrient deficiencies (3.1% for iron deficiency, 3.0% for vitamin A deficiency, and 3.2% for zinc deficiency), unsafe sex (10.2%), poor water, sanitation, and hygiene (5.5%), and indoor smoke from solid fuels (3.6%). However, high blood pressure, tobacco, and cholesterol were also in the 'top ten' in these countries.

In Table 16.1 we have collated Ezzati et al.'s (2002) top 20 global risk factors and the diseases they cause. To this, we have added columns on the factors which lead to such diseases, and in particular the novel technologies and behaviours underlying these factors.

Undernutrition is the leading cause of healthy life years lost across the world. This problem is primarily associated with a nexus of economic deprivation and repeated infection among mothers and children, and is improving, largely due to improvements in food availability and reductions in poverty worldwide. However, some major problems remain. Recent decades have

[1] See www.childinfo.org/mortality_imrcountrydata.php

[2] See www.globalhealth.org/infectious_diseases/

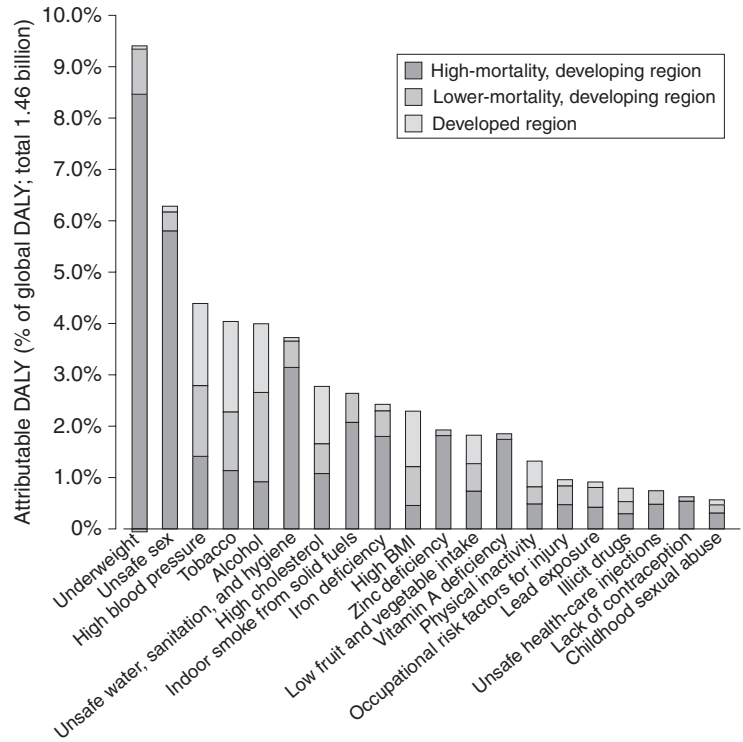

Fig. 16.1 Burden of disease dues to leading global risk factors globally and by region (reprinted from Ezzati et al. 2002).

seen major shifts away from exclusive breastfeeding and towards mass-produced milks and weaning foods. These more convenient novel food technologies deprive children of maternal immunoglobulins, vitamins, and protein, and expose them to environmental pathogens at an early age (Cousens et al. 1993; Black et al. 2008). Maladaptive behavioural responses to attractive new technologies (convenience foods) have been encouraged by marketing (Baumslag and Michels 1995), a recent cultural phenomenon which figures in many current public health problems.

Unsafe sex is the second most important cause of loss of DALYs, largely due to the HIV epidemic, which came about because of changes in sexual behaviour in recent decades (Quinn et al. 1986). The virus took advantage of changes in cultural values arising from rural–urban migration, driven by lifestyle changes and the use of illicit drugs (Udoh et al. 2009). Though a novel technology, the condom, is available to prevent the transmission of sexually-transmitted diseases, its use remains suboptimal, largely because condoms are unrewarding to use, interfering with the pleasure gained from our most basic reproductive motive (Valdiserri et al. 1989).

High blood pressure is the third biggest cause of loss of healthy life years. Contributory factors include diets high in refined salt, as well as inactivity and being overweight (Danaei et al. 2009). Tobacco and alcohol are the fourth and fifth causes of avoidable disease. While humans (and some animals) have always enjoyed consuming intoxicating substances, human ingenuity and the modern mass market have enabled unprecedented numbers to stimulate their reward centres cheaply and easily using refined products (Di Chiara et al. 1992; Kalivas and Volkow 2005).

Table 16.1 Risk factors for global burden of disease and contributory causes (from Ezzati et al. 2002)

Risk factor for burden of disease	Health Outcomes	Contributory causes	Novel technologies	Novel behaviours	References
1. Underweight	Malnutrition, infection, low birthweight	Economic factors, recurrent infection, industrialization and mass production of food	*Convenience foods**	Loss of traditional feeding practices (e.g. bottle feeding, weaning)	[1, 2]
2. Unsafe sex	STDs (HIV), cervical cancer	Rural-urban migration, social breakdown, sex industry, cultural factors	*Condoms*	Increased same and opposite sex promiscuity	[3, 4]
3. High blood pressure	Cardiovascular disease, stroke	Industrialization and mass production of food, sedentarization of work and leisure	Refined salt, sugar, oils, etc Labour saving and leisure technologies	Over-consumption, sedentary lifestyle	[5]
4. Tobacco	Cancer, heart disease, respiratory disease	Industrialization and mass production of cheap psychoactive drug	Tobacco high in available nicotine (cigarettes)	Smoking	
5. Alcohol	Cancer, heart disease, diabetes, depression, injuries	Industrialization and mass production of cheap psychoactive drug	Refined alcoholic drinks	Regular and binge drinking	
6. Water, Sanitation and Hygiene	Diarrhoeal disease, respiratory infection	Insufficient public/private investment in water supply and sanitation	*Soap, toilet, water treatment devices*	*Handwashing, toilet and water filter use*	[6]
7. High cholesterol	Cardiovascular disease, stroke	Industrialization and mass production of processed foods, sedentarization of work and leisure	Low density lipoproteins and trans fats	Use of processed foods, sedentary lifestyle	[5]
8. Indoor smoke	Respiratory disease	Cooking with solid fuels, house design	*Improved (gas/electric) stoves*	Use of solid fuels for cooking	

9. Iron; 11. Zinc; 13. Vitamin A deficiency	Anaemia, malnutrition, infection	Cereal-based diets, recurrent infection, helminth infection, early weaning	*Micronutrient supplements*	Consumption of cereals/ weaning foods	
10. Overweight	Cardiovascular disease, stroke, diabetes, cancer	Industrialization and mass production of processed foods, sedentarization of work and leisure	Refined salt/sugar/oils, labour-saving and leisure technologies	Over-consumption, sedentary lifestyle	[7–9]
12. Low fruit and vegetable intake	Cardiovascular disease, stroke, cancer	Industrialization, mass production of processed foods	Refined salt/sugar/oils	Preferential consumption of processed foods	
14. Physical inactivity	Cardiovascular disease, stroke, cancer	Sedentarization of work and leisure	Labour-saving and leisure technologies	Sedentary lifestyle	
15. Occupational	Injury	Industrialization	Industrial machinery	Interaction with machinery	
16. Lead exposure	Cardiovascular disease, mental retardation	Industrialization, mass production of automated transportation	Cars, lorries	Driving	
17. Illicit drug use	HIV, overdose, injury, infection	Production and marketing of cheap psychoactive drugs	Refined psychoactive compounds, syringes	Drug consumption/ injection	
18. Unsafe injections	Acute infection	Contaminated injections	*Syringes*	Syringe reuse	
19. Lack of contraception	Maternal mortality	Cultural factors, lack of access	*Contraceptive technologies*	*Uptake of contraception*	
20. Childhood sexual abuse	Depression, alcohol abuse	Cultural factors			

* Items in italics constitute technologies and behaviours that are, beneficial rather than detrimental to health (although they may be both). References: 1, Black et al. (2008); 2, Humphrey (2009); 3, Hamers and Downs 2004; 4, Quinn et al. (1986); 5, Danaei et al. (2009); 6, Bartram and Cairncross (2010); 7, Prentice (2006); Nesse and Williams (2005); Popkin (2003); Ezzati et al. (2003).

The communications technologies of the mass market have also allowed marketers to engineer cultural change towards making the use of such technologies socially normative. In the informal economy, the use of illicit psychoactive drugs is now widespread enough to be the seventeenth biggest burden of disease globally, again because they provide synthetic stimulus to the reward system. (Such psychoactive compounds may, however, also have had adaptive advantages, as recreational drugs can lead to promiscuity (Kurzban et al. 2010) and moderate drinking has been shown to be associated with improved longevity (Danaei et al. 2009)).

Environmental contagion is the sixth biggest cause of avoidable DALYs lost, due to a lack of clean water, sanitation, and hygiene, which affects mainly the poor in developing countries. These lead to morbidity and mortality from diarrhoea and acute respiratory infections, primarily in childhood. While public failure to invest in infrastructure is part of the problem, the failure of individuals to acquire and use the novel technologies of soap, water filters, and toilets is also an important reason that both children and adults suffer widely from these conditions.

Regular exposure to indoor smoke, caused by cooking in poorly ventilated shelters with solid fuels like wood and coal, is eighth on the list. It is associated with avoidable respiratory ailments (Ezzati and Kammen 2001). While electrification is advancing rapidly and propane gas is becoming more widely available, the problem of failure to acquire these new technologies remains widespread in poor rural areas of developing countries.

Micronutrient deficiencies in iron, zinc, and vitamins are widespread, primarily in developing countries. They cause anaemia and malnutrition, and are attributable to multiple causes including recent changes in diet and repeated infection (Stoltzfus et al. 1997; Miller et al. 2002; Black 2003).

Being overweight is the tenth most significant avoidable risk in the world. This is caused by our novel 'obesogenic' environment which mass markets highly stimulating refined, energy-dense foodstuffs, coupled with technologies which facilitate inactive work and leisure patterns (Popkin 2003). Obesity is particularly prominent in developed countries, although it is spreading rapidly in developing countries. While these countries are still struggling with underweight and the diseases of poverty, modern problems of obesity, heart disease, and diabetes are also on the rise, threatening to overwhelm already stretched health services (Prentice 2006). A recent OECD (Organization for Economic Cooperation and Development) study finds over 70% of Mexicans, and 50% of South Africans and Brazillians overweight, with rates in China and India increasing by as much as 1% annually (Cecchini et al. 2010).

Risk factor number 12, low vegetable and fruit intake, is at least partly due to alternative foodstuffs which are cheaper, more easily available, and more motivating to consume. If apples and cake are equally available, cake tends to be first choice (though preferences can be trained otherwise, with some effort). The 14th factor, lack of exercise, can largely be ascribed to novel technologies that make productive work less energy-consuming and sedentary leisure pursuits more attractive than active ones. Factor 15, occupational hazards, mainly concern injuries at the workplace, many of which concern the use of novel technologies (Leigh et al. 1999) (however, ancestral means of making a living may have been at least as hazardous). Factor number 16, lead exposure, can be ascribed to use of novel transport technologies, especially private cars, which are now cheap and widely available (Fewtrell et al. 2004). Finally, syringes (number 18) are a novel form of, mainly beneficial, technology, whose re-use in resource-poor settings leads to a major burden of infection (Kermode 2004), and novel contraceptive technologies (number 19), if more widely used, could substantially reduce the burden of maternal mortality (Campbell and Graham 2006).

While one could take issue with how Ezzati et al. (2002) carve up what is a highly complex web of interlinked disease causation, and some of the factors that they leave out (e.g. risk factors for

malaria, tuberculosis (TB), and depression) their widely-cited league table provides a snapshot of today's main public health problems. From Table 16.1 a striking pattern of technological and behavioural determinants of ill health emerges. The data shows that we endanger our health by consuming too much of some foods, too little of others, exercise too little, abuse psychoactive substances, and take risks with sex and cars.

Mismatched motivation

From an evolutionary perspective, the incidence and persistence of so much unhealthy behaviour is puzzling. Over evolutionary time, behavioural tendencies that lead to high morbidity and mortality should have been selected out of the gene pool (assuming they had no outweighing fitness benefits). Time, however, is exactly the problem. We have effected huge changes in the environments in which we live in just a few generations—particularly over the last 150 years or so—hardly enough time for there to have been any genetic changes to affect our psychological make-up. Technological advances have made possible products such as refined sugars, edible oils and salt, psychoactive substances, labour-saving devices, and fast cars, and made them easily accessible to the populations of mass-market economies in the space of a century. Our motives have led us to create these technologies and a mass market of exchange of innovation and value creation, with ever-increasing efficiency of production and distribution (Ridley 2010). So while accelerating innovation and mass-production in formal and informal economies has brought huge gains in public health (water supply, disposable nappies, better nutrition), it has also had significant negative consequences (obesity, addiction, violent death).

The pattern is striking: all of the top ten global causes of loss of DALYs can be ascribed to technological mismatches; either because of the widespread adoption of technologies with harmful effects (refined salt, sugars, oils, psychoactive compounds, sedentary leisure, guns, syringes) or the failure to adopt health-giving technologies (sanitation, soap, pills, bednets, bicycles). Why is this? Humans are equipped with a set of motives that cause us to behave in such a way as to meet our needs in the environments in which we evolved. Our ancestors—mammal, primate, pre-human, or *Homo sapiens*—needed to find food, mates, social partners, and other resources, and evolved brain systems to meet those needs (Aunger and Curtis 2008). However, those motives have also driven accelerating human innovation, leading to the invention and mass production of new technologies which have transformed living environments in all countries. Our motivated behaviour responds to these technologies and not to the ancestral objects and environments which 'designed' our brains.

The pattern is even more striking if we look at the top ten causes of burden of disease in developed economies, where nine of ten risk factors can be ascribed to this mismatch (tobacco, high blood pressure, alcohol, cholesterol, overweight, low fruit and vegetable intake, physical inactivity, illicit drugs, unsafe sex). A major feature of modern market economies is mass production. It reduces the cost of making products which are able to stimulate the senses in super-salient fashion (e.g. cigarettes, high-density foods), and hence causes widespread abuse of highly rewarding products. In this way, new technologies such as refined foodstuffs and stimulants, vehicles, and communication devices, which have been designed to be attractive and motivating to use, become ubiquitous. However, acquiring such technologies to gratify these medium-term desires can have long-term health consequences, such as obesity, cardiovascular disease, addiction, and injury. Since hunger, lust, and comfort are fundamental motives, products that save energy and effort, and meet our appetites, thus providing reward, readily spread. And products that can provide reward directly, via the intake of ethanol, nicotine, or other psychoactive compounds, are especially attractive.

For example, people have smoked tobacco for thousands of years. However, there is little suggestion that lung cancer was a common problem in populations which smoked low-grade tobacco (e.g. among American Indians, Europeans). What turned the habit from a low-grade irritation into a primary carcinogen and hence public health problem was the widespread use of cigarettes after World War II (Boaz 2002). Cigarettes contain finely shredded tobacco leaves wrapped in paper. The increased surface area of tobacco being burned at higher temperature delivers a much larger nicotine hit to the lungs, which is physiologically distinct from slow-burning twists of tobacco. Nicotine releases dopamine in the brain, which makes tobacco smoke a psychoactive drug working on the brain's reward system.

What distinguishes psychoactive compounds from other classes of substances is that they provide psychological rewards independent of having achieved an evolutionary goal. Other behaviours, to produce rewards, must rely on positive feedback from the environment—either in terms of consumption of resources, or feedback in the form of recognized signs of success (e.g. a smile on the face of a fellow group member, suggesting a status improvement). With psychoactive substances, reward comes from consumption of the substance itself, which directly stimulates the reward system (Pomerleau 1997; Nesse and Williams 1998). The technology associated with cigarettes mimics the natural reward system, and subverts standard choice mechanisms in the brain.

Accelerating innovation has also made a number of health protective technologies widely available. Toilets, water filters, soap, and condoms are novel technologies and probably a good investment, even for the poorest: however, their take-up and use is suboptimal. It can be argued that this is because we have no intrinsic motivation to use them: had they been available ancestrally, the adaptive advantages they conferred might indeed have led to them becoming attractive in the same way that clean water is. The same argument could be made for the failure to comply with treatment for diseases such as leprosy or TB, to submit to influenza vaccination, or to sleep under a bednet. Getting an injection, remembering to take pills, or using a condom involves effort for which there is little immediate reward, and sometimes a disincentive—they can hurt, take time, and interfere with the joys of sex, for example. Such novel technologies were not a part of our ancestral environment, hence we have not undergone selection to find their use rewarding.

The market mirrors our motivations—where the demand is mainly for curative products which alleviate the discomfort of sickness, rather than products which prevent it. Hence, effort is invested in innovation for technologies of treatment rather than prevention, and people underutilize opportunities to vaccinate themselves, or to screen themselves for early signs of disease. The market has also failed to design and deliver technologies that can definitively rid us of many important infectious diseases, such as malaria, TB, and leishmaniasis.

The market also modifies our motivated responses. Modern marketing methods often exploit two other motives—status and affiliation. Technologies can be invested with status enhancing abilities, through celebrity endorsement for fast cars, for example (Miller 2009), and can become the norm to copy—when the cool guys in class and the majority seem to binge drink we may employ our 'copy the successful' and 'copy the frequent' tendencies, which also evolved for good evolutionary reasons (Richerson and Boyd 2005).

In a nutshell then, the reason that we do not behave optimally, as far as our health is concerned, is that there are alternatives to healthy behaviour that are more rewarding. Oily, salty, and fatty food is more rewarding than the alternatives and our desire to consume them preferentially has led the market to make such foods cheap and easy to access. If a healthy option exists, it often is not intrinsically rewarding and is not widely taken up. Our once-adaptive preference for minimizing exertion has led to dramatic shifts away from energy-intensive occupational, leisure, transport, and domestic production activities (Popkin 2003). Our desires for cheap transport and

for technologies of self-defence have unlooked for side effects, driving a rise in violent death due to accidents, anger, and depression. The use of alcohol, tobacco, and illicit drugs are on the rise because they are cheap and rewarding to use in the short term, but they damage health in the medium- to long-term. Condoms, bednets, soap, vaccinations, prescribed medicines, and toilets can be unrewarding to acquire and use in the short term, despite their long-term health benefits.

Evolutionary health promotion in practice

What then can be done about motivational mismatch? Are we doomed to face an ever-rising tide of obesity, addiction, and violence? Can we improve the uptake of health-giving technologies? First, we analyse one case study from this perspective—the problem of how to promote safe hygiene—and then reflect on the general applications of such evolutionary thinking to the public health problems that we have been discussing.

Much of our own work focuses on the prevention of diarrhoeal disease, the second biggest killer of children in developing countries, accounting for over 1.5 million deaths a year (Boschi-Pinto et al. 2008). Systematic reviews suggest that handwashing with soap (HWWS) is probably the most effective, and cost-effective, means of preventing this problem, cutting rates of diarrhoeal disease by 42–47% (Curtis and Cairncross 2003; Cairncross et al. 2010) and rates of respiratory infection by 23% (Ensink 2004; Rabie and Curtis 2006). One review of interventions to reduce the burden of disease in developing countries put hygiene promotion, including HWWS, as possibly the most cost-effective intervention of all (Jamieson et al. 2006).

Yet soap is a relatively novel technology, one that has only been mass-produced for about 150 years (Wilson 1954). Purchased regularly by almost all households of the world for the purposes of body and clothes washing, soap is still rarely employed on hands (Curtis et al. 2000) to prevent the faecal–oral transmission of diarrhoea-causing microbes (including *Escherichia coli*, *Salmonella*, *Shigella*, rotavirus, *Campylobacter*, *Vibrio cholera*, etc.). When asked, most people say that they wash hands with soap, however, we found that directly observed HWWS after toilet use stood at only 3% of mothers in Ghana and in rural India (Biran et al. 2009), 13% in rural China, 14% in Peru, 18% in Kyrgyzstan, and 29% in Kenya (Curtis et al. 2009). Handwashing is not so much better in the UK. In one study, we found that only 43% of mothers washed hands with soap after changing a dirty nappy. In a motorway service station, electronic counters revealed that only 32% of male and 64% of female toilet users used soap (Judah et al. 2009a). Of commuters in a sample of UK cities, 28% had bacteria of faecal origin on their hands (Judah et al. 2009b).

Over a period of 10 years we have been carrying out formative research studies to try to understand handwashing behaviour, so as to improve it. We have data from more than 12 countries in most geographical regions. A focus of the studies was to identify the motives that could be used to drive the use of soap for handwashing. We hypothesized that these would include disgust, fear, nurture, comfort, attraction, and affiliation. (Note that each motive has a technical definition according to its adaptive origins: for example, disgust as the driver of infection avoidance behaviour (Curtis et al. 2004); fear for harm avoidance from accident and violence; comfort for physiological equilibrium-seeking behaviour; nurture for child care behaviour; attraction for mate-seeking and adornment behaviour; status for social influence-seeking behaviour; and affiliation as the driver of group-adherence seeking.)

Most of the research has been qualitative (Curtis et al. 2009), but quantitative studies provide similar findings (Aunger et al. 2009). Key conclusions are surprisingly similar from country to country. Respondents almost always know of the health benefits of HWWS, but this fails to translate into practice. Key motives for HWWS were disgust, comfort, nurture, and affiliation. Physical settings, such as lack of easily available water, reduced, but did not prevent soap use.

A key role for disgust

Of all of the potential motives for HWWS, one in particular jumped out from the series of formative studies. Women everywhere said they washed their hands when they felt or smelled disgusting. They could only falteringly explain this: 'Because they are *yuk*, I can't explain, they are just *yuk*', went a typical interview. The most commonly mentioned contaminants were fish, excreta, and rotten or dead material, often of animal origin. Hands that had been in contact with faeces had to be washed. The fear of being perceived as dirty or disgusting by others was also a powerful motive for hygienic behaviour.

A series of studies on disgust helped to confirm our hypothesis that disgust evolved to drive the behaviours that prevent contact with infectious agents. The disgust system in the brain responds to cues indicating sources of infection risk in the environment, and orchestrates appropriate avoidance behaviour (Curtis and Biran 2001; Curtis et al. 2004). The system is tuned by exposure and cultural information; learning what it is best to avoid in local circumstances (Curtis et al. 2011).

Disgust should therefore be the motive that is most appropriate for the promotion of infection reduction behaviour, such as HWWS. This idea was fed into a commercial creative process to design national marketing campaigns (Curtis et al. 2007). In Ghana, the agency Lintas produced a powerful television commercial[3] depicting a mother emerging from a toilet with a purple stain on her hands—this was then transferred to the food that she prepared, and then to the child that ate it. In screenings, mothers found the advert powerful and shocking. After 6 months of a high-intensity nationwide media campaign, reported handwashing rates increased by 13% after using the toilet and by 41% before eating (Scott et al. 2007).

We further tested a variety of messages displayed at the entrance to public toilets in the UK, electronically monitoring the impact on soap use. Disgust-based messages such as 'soap it off or eat it later' and 'don't take the loo with you—wash with soap' worked significantly better than control messages (Judah et al. 2009a). Elsewhere, Porzig-Drummond et al. (2009) tested disgust-based handwashing interventions in the lab and in a public toilet, and in both situations found that the disgust motive worked better than hygiene education.

Other motives for handwashing with soap

The above studies suggested that motives other than disgust were also important drivers of hygiene behaviour. Mothers tended to do whatever everyone else in their village was doing; a typical comment was 'handwashing with soap is just not something we do around here'. Affiliation to local social norms of non-use of soap can therefore help to keep use rates low, but if the social norms support soap use, this can increase its uptake. Our public toilet experiment confirmed this effect. HWWS rates were higher at times when there were more people using the toilets and also when the message 'Is the person next to you washing hands with soap?' was displayed at the entrance. A key lesson was that public campaigns should never comment on how low soap use rates are, for fear of driving rates even lower, but should rather try to make HWWS appear common and the norm, because the affiliation motive will then drive it up (Perkins 2004).

Other potential motives that could drive increasing use of soap were status and attractiveness; however, as HWWS is not socially very visible, it is hard to use this motive to drive soap use. Mothers also wanted soap for its comfort value: even extremely poor families would often choose to purchase luxury bath soaps because they have a pleasing odour and do not dry the skin out.

[3] See it at www.globalhandwashing.org/multimedia

Though traditional health education campaigns attempt to enlist fear of disease as a motivating factor, explaining to mothers the dire consequences of failure to improve their behaviour, our studies made it clear that this strategy was unlikely to work. Mothers already 'knew' of the health risks of poor hygiene, but regarded possible diarrhoea as a distant threat, one that was unlikely to be life-threatening, and one that was more often due to causes outside their control. Fear of disease only became relevant during local disease scares. HWWS rates in Kenya were unexpectedly high and were plausibly explained as a temporary response to a current cholera epidemic. Data from our public toilet research in the UK, collected during the recent H1N1 swine flu epidemic, suggested that HWWS peaks and then falls back to pre-epidemic levels, suggesting that fear responses in such epidemics may be short-lived.

While we have used evolutionary reasoning to seek for motives that might be key in driving the use of soap, necessary because it is a novel technology for which people have no intrinsic affinity, we are not the first to discover these drivers of soap use behaviour. The company Procter and Gamble (PandG) employed disgust in their early advertisements for Zest soap, where they claimed other soaps left a scummy residue, while Zest left skin truly clean.[4] The comfort motive has been employed repeatedly by advertisers. For example, a 1957 advert for Unilever's Dove soap claimed that it 'doesn't dry your skin'.[5] Soap has also long been sold using the affiliation motive, suggesting you need soap to be an accepted member of society ('From your head down to your toe, a daily bath with Lifebuoy will stop B.O.'[6] or to be attractive ('Don't wait to be told, you need Palmolive Gold').[7] P&G's advertisements for Camay soap make the attraction motive even more explicit.[8] Finally, soap companies also recognized that soap could be sold using the nurture motive, mother's desire to care for and groom their children (see, for example, Johnson and Johnson's Indian baby milk soap advert.[9]

In many countries the conclusions of our formative research on HWWS were fed into a process based on commercial marketing, where creative professionals were briefed to develop interventions based on the motives that we identified, that could be applied on a mass, a community, or a family/individual basis, depending on the available channels of communication and budget (Curtis et al. 2007). Results were encouraging, with substantial measurable improvements in handwashing rates (Curtis et al. 2001; Scott et al. 2007).

The problem of novel technologies

Soap is an example of a novel health-enhancing technology. While hygienic behaviour evolved before humans did (being manifest throughout the animal kingdom), soap was invented only recently (by the Babylonians, Egyptians, or in the Middle Ages, depending on which authority you consult: Curtis 2007; Smith 2007), and has only become commercially available to the majority in the last hundred or so years. There is no intrinsic, evolved motivation to use soap—the advantage it confers is too recent to be reflected in brains. The problem is, therefore, how to make rubbing onto the skin a bar of sodium stearate (plus additives), then rinsing it off, a rewarding and hence motivating activity. Our efforts, and those of commercial marketers, have shown how soap use can become motivating to help avoid disgust and shame, as an aid to nurturing children,

[4] See www.youtube.com/watch?v=_96T_DRNNW8andNR=1
[5] See www.youtube.com/watch?v=SMtqXC20D8g
[6] See www.youtube.com/watch?v=astrjgUhc2Iandfeature=related
[7] See www.youtube.com/watch?v=cfP-wASMikQ
[8] E.g. http://www.youtube.com/watch?v=CLrNXz55k4wandNR=1
[9] See http://www.youtube.com/watch?v=PZTZIkC46Gk

and as an aid to affiliation via social norms. These efforts create new mental associations between ancient motives and new technologies. We are now engaged in an industrial design process in pursuit of new hand-cleansing technologies that are intrinsically more motivating to use (by making a more convenient or attractive product). Through a combination of an available, appealing product and effective promotion targeted at key motivations, as well as support from soap companies, the hope is that HWWS may become a normative behaviour in society, no longer dependent on the persistent efforts of health promoters.

Are there general lessons that can be drawn from this work that can be applied to other new health technologies, such as pills, injections, condoms, bednets, and toilets? We believe so. For example, consumer research showed that toilets might best be marketed, not for their health benefit (as governments and non-governmental organizations do at present), but for new values such as *status*, *comfort*, reduced *fear* of snakes or attacks at night, and through avoidance of *disgusting* faecal matter in open defecation fields (Jenkins and Curtis 2005). Research into the low uptake of insecticide-treated bednets showed that they might be better marketed as an aid to the *comfort* of a good night's sleep rather than for the health benefit they might confer (Guiguemde et al. 1994). Condom marketers have long realized that health messages are not the best way to sell condoms. The Durex company, for example, now aim to sell them as an aid, rather than as a deterrent to sexual attractiveness.[10]

Beating mismatch

If it is possible to attach new motivations to products for which we have no intrinsic affinity, might it also be possible to use the same approach to discourage the unhealthy behaviours which are the source of most ill health in developed countries? Potentially. Novel technologies which have unhealthy consequences when consumed excessively (e.g. cigarettes) can also become associated with new motivational values. The British Heart Foundation advertisement series which associated disgust with cigarettes was thought to have been highly effective.[11] It has been suggested, however, that realization of the effects of smoking on the health of others was the main reason for its steep decline in recent years. Campaigners and legislators pointed out the injustice of harming others and imposed smoking bans in public areas, relying on the human need to affiliate to drive cessation (Christakis and Fowler 2008; although harmful technologies can, of course, also be made less attractive through public policy, such as by increasing sales tax or restricting access).

Take another public health problem: obesity. Most of the food types that dominate present diets were introduced quite recently: dairy products, cereal grains (especially refined grains that lack germ and bran), refined sugars (especially sucrose and fructose), refined vegetable oils (with low ω-3 and high ω-6 fatty acids), alcoholic beverages, refined salt, and ω-6 saturated, fatty, acid-rich, mammalian meats. These foods have displaced the wild plant and animal foods of our predecessors. Research shows that rats' brains react to these sweet, fatty foods in the same way that addicts' brains respond to cocaine. Thus 'conditioned hypereating' (Kessler 2009) works the same way as other 'stimulus response' disorders in which reward is involved, such as substance abuse. Furthermore, it has been suggested that some food companies are developing products that trigger compulsive overeating (Power and Schulkin 2009).

One solution that has been advocated is a return to ancestral diets (high in fibre, low in salt, carbohydrate, and fat: Milton 2000, 2002). However, such foods are outcompeted in supermarket

[10] See www.youtube.com/watch?v=yyahoTR1Otkandfeature=fvst

[11] See www.youtube.com/watch?v=ef3gofQcOKk

baskets by highly-motivating, highly-processed, super-stimulating, calorific foodstuffs, supported by sophisticated marketing employing motives such as status. Motivated by the threat of legislation and pressure from consumers, some global food companies are now investing effort in designing products that are both healthy and motivating. Drinks containing artificial sweeteners rather than sugar, and prepared fruit snacks that make fruit easier to consume, are early examples of what looks set to become a major trend.[12] Marketers can appeal to nurture and affiliation motives to make feeding healthier food (at least to children) both rewarding and normative.

Modern marketing is thus a social invention that can be used not only by commercial businesses to promote unhealthy products, but also by companies—and public health programmes—to make their health-promoting messages more effective at changing behaviour on a large scale. Industries can also turn their attention to developing products that meet the unmet needs of the poorest who are currently excluded from the benefits of modern technologies. Cheap (but still attractive) technologies such as water filters and insecticide-impregnated bednets can be designed and successfully marketed to the large consumer base at 'the bottom of the pyramid' (Prahalad 2005).

Conclusion: evolutionary public health

The idea that a 'mismatch' between ancestral conditions and modern lifestyles can lead to health problems is not new (Eaton et al. 1988; Williams and Nesse 1991). However, to date, there has been no systematic analysis of motivational mismatch as it applies to modern health problems, nor of the implications of this analysis for action to improve health.

Here we have seen that of the top ten risk factors for loss of DALYs, six (unsafe sex, high blood pressure, tobacco, alcohol, high cholesterol, overweight) are mainly due to mismatch and for the other four (underweight, iron deficiency indoor smoke, lack of water sanitation and hygiene), mismatch plays a part. Of the top 20 risk factors, 13 are directly due to mismatch and mismatch plays a part in the most of the rest. In developed market economies, fully nine out of ten of the main risk factors for loss of health can be attributed to motivational mismatch (tobacco, high blood pressure, alcohol, cholesterol, overweight, low fruit and vegetable intake, physical inactivity, illicit drugs, unsafe sex).

From an evolutionary public health perspective, these health problems come in three categories. The first is lack of uptake of health-giving technologies such as sufficient foods, micronutrient supplements, sanitation, soap, contraception, condoms, and cooking stoves. Poverty and underdevelopment is part of the reason why health-improving technologies are not more widely used, but another is that many of these technologies are evolutionarily novel and not intrinsically motivating to acquire or use, even if they are available. The second category is the overconsumption of highly-motivating novel technologies with direct ill-effects (tobacco, alcohol, psychoactive drugs, and foods high in salt, fat, and carbohydrate). These are intrinsically rewarding (or mimic the brain's reward system). The third category contains motivating novel technologies with harmful side effects such as labour-saving means of production, leisure, and transport, which reduce physical activity and sometimes cause injury (e.g. by producing environmental toxins, or by introducing infection on re-use in the case of syringes).

Societies are increasingly moving away from conditions that resemble the ancestral environments in which our motivational systems evolved, towards those with modern industrial

[12] See, for example www.sustainable-living.unilever.com/the-plan/nutrition/

economies and plentiful novel technologies, favouring the diseases of mismatch. Finding solutions to these problems is thus becoming more urgent. Poorer countries, particularly, increasingly face a double burden: not having yet cured the diseases of poverty, they simultaneously face inexorable rises in the panoply of modern diseases: cardiovascular disease, diabetes, cancer, and substance abuse.

So does this diagnosis, based in evolutionary public health, offer us new solutions to these intractable problems? We have suggested that they do. The link between novel technologies and psychological rewards underpins our argument that public health interventions must either curb an evolved motivation exploited by a problematic novel technology, or associate use of a health-beneficial technology with some new reward which increases its level of use. For example, cigarette smoking, which provides artificial rewards directly to the brain, can be curbed by linking that practice to disgust or disreputable people. Or use of a condom can be linked to the rewarding notion of being what a 'real man' does. In this way, a mismatch between some evolved motive and a novel technology which currently leads to a public health problem can be 'matched' with a different reward to help solve the problem.

Our analysis also suggests that health can be improved, not just by focusing on behaviour, but by improving the technologies on offer. For the poorest, more can be done to find cheap and attractive technologies that meet basic needs (protection from insect vectors of disease, improved simple toilets, new hand-cleansing technologies). For the better-off, more can be done to make healthy options more attractive (active sports, healthier food products, alternatives to smoking and drinking). Modern marketing techniques have much to offer public health practitioners (Curtis et al. 2007). Consumers and regulatory authorities will increasingly provide the carrots and sticks that will give a competitive advantage to those manufacturers of consumer products who strive to enhance health.

Taking an evolutionarily informed approach to public health thus has a number of benefits. It allows us to see public health in a long-term perspective, showing how patterns of disease and behaviour have changed as we have modified our settings. It highlights how our evolved motives have led us to create a world that is much better at meeting our needs than it ever has been (Ridley 2010). This has had major health benefits, but also given us the diseases of mismatch that now are amongst our biggest global health problems. We have argued that understanding the evolved motivational drivers of behaviour gives us a useful perspective, not just into the reasons why we fail to behave healthily, but also into means of promoting safer behaviour. Our lesson for the public health practitioner is this: motives got us into this mess but they can also get us out, if only we systematically understand the ways in which motivational mismatch works.

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