



Perspective

Rudolf Virchow and disease prevention and health promotion in the 21st century

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Abstract

The German pathologist and politician Rudolf Virchow played a pivotal role in promoting social medicine and improving public health in the 19th century. Virchow's main achievements include his characterisation of medicine as a social science as well as a biological science. His fundamental goals included the founding of the practice of medicine on the exact sciences as well as the prevention of disease and promotion of health through social and political action. According to Virchow, the remit of medicine was not merely to treat disease but also to contribute to the health of the entire population. Today, disease prevention and health promotion should become priorities in global and national political agendas and investment decisions. The key factors contributing to the global pandemic of non-communicable diseases are unhealthy lifestyles, with high-calorie diets, insufficient physical exercise, tobacco smoking and alcohol use. These lifestyle factors also contribute to the susceptibility to severe acute respiratory syndrome coronavirus type 2 infection and a more severe course of coronavirus disease 2019. Prevention of the development of non-communicable and age-related diseases would reduce the future demand on healthcare systems. Interventions capable of slowing ageing and reducing the number of disability-adjusted life years may have a greater benefit than those targeted at individual disease. Decisive political leadership is required to motivate significant changes in health improvement in respect of both infectious and non-communicable diseases. Governments worldwide need to pay serious attention to the wellbeing of the people and should institute lasting and meaningful changes at population level.

Keywords: Rudolf Virchow; Disease Prevention; Health Promotion; Non-communicable diseases; Public Health.

1. Introduction

"In history, a great volume is unrolled for our instruction, drawing the materials of future wisdom from the past errors and infirmities of mankind" (Burke, 2009). This exhortation to learn from history from the Irish statesman Edmund Burke, writing in the 18th century, is still valid today. Medical history offers lessons for present-day health practitioners and politicians in their development of policies addressing pressing public health issues. In view of the current pandemics of both communicable (infectious or transmissible) and non-communicable (chronic) diseases, it is appropriate to remember the manifold contributions to the field of disease prevention and health promotion of the German physician, pathologist, public health pioneer and politician, Rudolf Virchow, who was born 200 years ago on October 13th, 1821 (Lange, 2021a).

Rudolf Virchow is remembered primarily as the creator of the enduring cell doctrine in pathology (Malkin, 1990). Virchow's best-known work, amongst his more than 2000 publications, is his book "Cellular Pathology" (Virchow, 1978), which, based on his findings of observable lesions of specific cells in inflammation, degeneration and tumour growth, presents the cell as the fundamental unit of physiological and pathological processes and therefore as the centre of disease. Virchow's numerous contributions to special pathology include, for example, the discovery of amyloidosis and leukaemia. He established the pathophysiology of thrombosis and pulmonary embolism and introduced designations of many tumours that are still in use today (Virchow, 1863). At the level of the entire organism, Virchow emphasised the concept of the interrelationship and integration of multiple processes, which may eventually lead to pathologically relevant alterations. The

classic factors of the triad ascribed to Virchow, which precipitates the formation of a venous thrombus, illustrate this concept. Cellular lesions of the endothelial wall of a vein, together with haemodynamic changes (stasis of blood flow) and increased blood coagulability, may cause a thrombosis in a vein of the lower limbs, which in turn may become the origin of a distant effect in the lung in the form of pulmonary thromboembolism (Bagot and Arya, 2008).

As a physician with a wide range of clinical and scientific interests, Virchow also made important contributions to anthropology, ethnography, prehistory and especially epidemiology and public health (Ackerknecht, 1953). Virchow's concepts of socio-medical causation and social medicine addressed the social, environmental and economic aspects of illness (Lange, 2021b). He attempted to integrate findings from different levels of biological complexity, e.g. from cellular biology and chemistry to population and society, and to provide a unified explanation of the interaction of physical and social influences causing disease (Ackerknecht, 1953). Virchow's eminent position in medical history derives from both his bioscientific and social medical contributions, including socio-epidemiological studies, health policies and strategies of socio-medical change (Waitzkin, 1981).

2. Socio-medical causation of disease and public health

Virchow's interest in socio-medical causation and public health was moulded by his observations during a severe outbreak of louse-borne typhus fever in Upper Silesia in southeastern Prussia. The failure of the local authorities to contain this epidemic led to a widely noted public scandal. Consequently, in 1848, Virchow was appointed by the Prussian government to a commission tasked with investigating the epidemic and submitting recommendations for its alleviation. Virchow's uncompromising and scathing report concluded that the typhus epidemic was a social rather than a medical problem since its effects were concentrated among the poor peasantry rendered vulnerable to disease by malnutrition, bad housing, lack of sanitation and hazardous working conditions (Virchow, 1848). The report was expressed in radically anti-establishment terms, typifying the social and political radicalism of the 1840s in Germany and other European nations. Virchow regarded the typhus fever outbreak as a complex interaction of social, economic and political factors. The root causes, in his view, were governmental neglect, political oppression, poverty, illiteracy and religious exploitation. He expected little from medicinal or palliative interventions and proposed, instead, more radical remedial action as a means of preventing similar crises. Foremost in his policy objectives was social reform, comprising advances in education and democracy, improvement of living conditions and prosperity as well as personal freedom and elimination of social inequality (Virchow, 1848). Hunger, ignorance and servitude should be replaced by wealth, education and freedom. The much-needed advancement of the entire population would entail a social revolution, whose

explosive potential must be moderated by a reformist élite, including physicians, exercising its power through a benevolent state (McNeely, 2002). Scientific rationality formed the outlines of Virchow's social politics, as indicated in his statement that, "medicine is a social science, and politics is nothing more than medicine on a grand scale" (Mackenbach, 2009).

Virchow's report of the typhus epidemic can be seen as both the foundation of a political programme and a key document in the history of social medicine. Virchow demanded political change as a solution to medical problems and developed a commitment to revolutionary social change, with the primary objective of improving the welfare of the working class. He became a political activist, was among those manning the barricades in Berlin during the German revolution in March 1848 and founded the weekly newspaper "Die Medicinische Reform" (Medical Reform), which was published from 1848 to 1849 (Goschler, 2002). Although claims have been made that the identification of social medicine and some of the radical political contributions commonly credited to Virchow should, in fact, be attributed to the other editors of "Die Medicinische Reform", Virchow's powerful role as spokesman and figurehead of the medical reform movement remains undisputed (Ackerknecht, 1953).

When the 1848 revolution failed, Virchow, in consequence of his political activities, was suspended from his position as assistant professor in pathology at the Charité Hospital in Berlin. In 1849, he was appointed to the first chair of pathological anatomy in Germany at the University of Würzburg in Bavaria. In 1856, he was allowed to return to Prussia to become professor of pathology at the Charité, where he remained until his death in 1902 (Goschler, 2002). In later life, Virchow continued to challenge Germany's ruling class, but chose less combative means of expression. He was a long-serving parliamentarian in Prussia and the German Reichstag and became an outspoken and impassioned advocate for the public health movement.

On the basis of his observations of the typhus epidemic in Upper Silesia, a famine in the Spessart region, outbreaks of tuberculosis in Berlin and an increase in the morbidity and mortality rates in working-class areas of European cities, Virchow emphasised the major influence of social circumstances in the dissemination of illness and the emergence of epidemics (Virchow, 1985). He linked disease, disability and premature death to poor material conditions, which rendered people more susceptible to other morbid causes, none of which would suffice in isolation to produce an epidemic (Virchow, 1879). Prevention was central to Virchow's concept of a public health service, and he contributed widely to the field of preventive medicine. Virchow worked on a wide range of public health measures, such as enhancing medical services for the poor and introducing vaccinations for children (Ackerknecht, 1953). Virchow successfully accomplished a sanitation reform and implemented various sanitation projects. For example, as a politician, he fought for safe drinking water supplies and sewage removal. The underground sewage disposal system designed by him in Berlin set an example for similar policies in Germany and

other countries. Furthermore, he supported children's vaccinations and gymnastics lessons for girls (Andree, 2002; Goschler, 2002; Balkhausen, 2007).

Through his identification of the relationship between social conditions and illness, Virchow came to be credited as the founder of social medicine as a scientific discipline, and his influence has endured to the present day. However, the relevance of social medicine in the modern age of molecular medicine, with human genome research promising novel diagnostic and therapeutic methods, may be questioned. Similarly, in Virchow's lifetime, new scientific developments, such as the discovery by Robert Koch and Louis Pasteur of bacteria as causative agents involved in infectious diseases, contributed enormously to the progress of medical science and brought the tenets of social medicine into question. This challenge to the theoretical underpinnings of Virchow's belief in socio-medical causation led him, possibly as an overreaction to the threat to his own theory, to reject the microbial theory of disease and to oppose, for example, Koch's identification of the tubercle bacillus as a key factor in the aetiology of tuberculosis. Virchow modified his anti-contagionist position to some degree in later life (Rosen, 1947).

3. Infectious diseases in the 21st century

Virchow's conclusions regarding the aetiological impact of social and societal factors are as valid today as they were in the mid-19th century. Some 140 years after Virchow's report, another health account from Upper Silesia concluded that increasingly high rates of infant mortality and child morbidity could be attributed to socio-economic factors such as poverty, smoking, alcohol and drug use as well as stressful living conditions in urban centres (Chopin, 1992). During a more recent typhus epidemic in Burundi in the 1990s, widespread epidemic typhus was observed to occur only if extensive spread of body-lice infection was promoted by social conditions, such as the displacement of an entire population (Raoult et al., 1998). Furthermore, outbreaks of the louse-borne form of relapsing fever or epidemic typhus have been found to occur typically in the wake of famine, wars and other large-scale disastrous events characterised by malnutrition and crowded and unhygienic living conditions (Southern and Sanford, 1969).

As in Virchow's times, tuberculosis is still a consequence of widespread and sustained poverty, poor living and working conditions, unequal access to health care and socially determined unhealthy behaviours (Raviglione and Krech, 2011). Virchow's characterisation of tuberculosis as a social disease has shaped preventive measures and public health strategies (Sudhoff, 1922). Emerging welfare states adopting the view of tuberculosis as a social disease saw a significant decline in its prevalence in the first decades of the 20th century, before effective medications for tuberculosis were introduced (Raviglione and Krech, 2011). In 1949, the death rate from pulmonary tuberculosis was stated to be a sensitive index to the social state of a community (Chisholm, 1949). The availability of

drugs against tuberculosis gradually shifted the focus from population-based prevention through social development to curative approaches in those infected, giving rise to hopes that the sole use of medical interventions could eliminate tuberculosis in low-income countries, without the need for an improvement in living standards (Ramakrishnan et al., 1961). Health services capable of delivering high quality diagnosis and treatment of tuberculosis have significantly contributed to a decrease in prevalence and death rates. Nevertheless, the total number of individuals with tuberculosis continues to rise globally due to demographic factors (Raviglione and Krech, 2011). Therefore, the target for the elimination of tuberculosis set by the World Health Organisation for 2050 is unlikely to be met (Lönnroth et al., 2010).

In the current coronavirus disease 2019 (COVID-19) pandemic, infection risk, disease course and case fatality rates are also linked to social inequalities, such as inferior education, low socio-economic status and poverty (Karmakar et al., 2021; Rocha et al., 2021). Socio-economic inequalities are associated with the acceptance of social distancing regulations, with lower levels of compliance in United States communities comprising higher numbers of people below the poverty level (Garnier et al., 2021). A number of recent studies have reported strong associations between COVID-19-related outcomes and socio-economic and racial-ethnic minority status in Chile and the United States (Hawkins et al., 2020; Karmakar et al., 2021; Mena et al., 2021). In the United Kingdom and United States, socio-economic inequalities have been found regarding infection risk and severity of the course of COVID-19, with socio-economically less privileged sections of society being affected more severely (Wachtler et al., 2020). In Brazil, socio-economic inequalities have been shown to affect the course of the COVID-19 epidemic more significantly than age, health status or other risk factors, with a disproportionate adverse burden on regions with a high degree of socio-economic vulnerability (Rocha et al., 2021). Individuals with higher levels of education in Brazil were 44% less likely to die from COVID-19 (De Negri et al., 2021), and lower educational attainment was strongly associated with elevated rates of both COVID-19 cases and fatalities in the United States (Hawkins et al., 2020). Furthermore, infection fatality rates in young people, which are usually very low, were found to be higher in low-income city municipalities (Mena et al., 2021). These findings highlight the critical consequences of socio-economic inequalities on health outcomes during the current pandemic.

4. Non-communicable diseases in the 21st century

A continued epidemiological shift from communicable to non-communicable diseases as well as from premature death to years lived with disability has been well documented (Murray et al., 2012). Non-communicable diseases have emerged undisputedly as a predominant challenge to global health in the 21st century (Yach et al., 2004; Murray et al., 2012). Even in low-income countries, non-communicable diseases are rapidly

becoming a bigger problem than infectious ones. The Global Burden of Disease Study has shown that, between 1990 and 2016, the worldwide average for healthy life expectancy at birth increased from 55 to 61 years for men and from 58 to 65 years for women (GBD 2016 DALYs and HALE Collaborators, 2017). This rise was due mainly to lower rates of infectious diseases, such as AIDS, malaria and tuberculosis, and lower neonatal death rates. However, the burden of chronic conditions has risen. Since 1990, the number of disability-adjusted life years, which is an estimate of the time lost to disability and early death, due to diabetes and kidney disease has increased by 24% and 20%, respectively. Furthermore, more than one billion people worldwide have been found to have uncontrolled hypertension, a risk factor for many non-communicable diseases (World Bank and World Health Organisation, 2017).

Non-communicable diseases carry a huge cost both in terms of human suffering and damage caused to a country's economy and social fabric. These diseases are the leading cause of death worldwide and accounted for 41 million (71%) of the world's 57 million deaths in 2016 (World Health Organisation, 2018), with the four major chronic diseases: cardiovascular diseases (17.9 million deaths), cancers (9 million deaths), chronic respiratory diseases (3.9 million deaths) and diabetes (1.6 million deaths) causing 80% of all premature deaths resulting from non-communicable diseases globally (World Health Organisation, 2018). In the United States, non-communicable diseases account for most of the health-care expenditure (Centers for Medicare and Medicaid Services, 2012; Hoyert and Xu, 2012; United Health Foundation, 2012) and are the main cause of poor health, disability and death. Approximately 50% of adults in the United States have at least one chronic condition and 26% have two or more conditions (Ward and Schiller, 2013). In China, chronic diseases have become a leading health threat, accounting for an estimated 80% of deaths and 70% of disability-adjusted life-years lost (Wang et al., 2005).

Socio-medical causation is not confined to infectious diseases but also involves the present-day pandemic of non-communicable diseases. While the death rate from pulmonary tuberculosis is generally accepted as a sensitive index of the social state of a community, this also holds true for chronic conditions (Krech, 2011). Obesity provides an example illustrating that non-communicable diseases cannot be addressed effectively without action affecting the social determinants of health and disease. The prevalence of obesity has tripled since 1975, and approximately two billion people globally are overweight (World Health Organisation, 2020). Obesity rates have risen sharply not only in high-income countries, but also in low- and middle-income countries (U.S. Department of Health and Human Services, 2000; Flegal et al., 2002; Schoenborn et al., 2002; James, 2008). For example, obesity rates in China and India have increased several fold (Misra and Khurana, 2008; Low et al., 2009). In consequence, the World Health Organisation declared obesity a pandemic in 2000 (World Health Organisation, 2000). Key drivers of the increasing global rates of obesity have been the decrease in daily energy

expenditure due to increased physical inactivity, and the growing consumption of high-energy diets, including fast foods and sugar-rich soft drinks (Harnack et al., 1999; Cavadini et al., 2000; Kant, 2000; Ludwig et al., 2001; Zizza et al., 2001; Nielsen et al., 2002; Putnam et al., 2002). People with a lower socio-economic status have been shown to consume such diets, which provide inexpensive, concentrated energy from sugar, fat and processed meat with relatively little intake of vegetables, whole grains and fruit (Reicks et al., 1994; Quan et al., 2000).

In the United States, the rates of obesity and type 2 diabetes have been shown to follow a socio-economic gradient, with the burden of disease disproportionately affecting the poor and racial-ethnic minorities (U.S. Department of Health and Human Services, 2000). The highest obesity rates have been shown to be associated with low income and low educational levels (Schoenborn et al., 2002), with people living in counties with poverty rates of more than 35% experiencing obesity rates 145% greater than those in wealthy counties (Levine, 2011). Healthy diets have been shown to be associated with higher income and education, while unhealthy diets have been associated with overweight and obesity (Bowman et al., 1998). The effect of socio-economic status on diet quality has frequently been explained by higher educational level or greater awareness of health issues among people with higher income (Bowman et al., 1998). However, knowledge of healthy nutrition is not necessarily linked to a healthy diet (Patterson et al., 1996; Tepper et al., 1997; Berg et al., 2002). Associations between food insecurity and obesity have been found (Alaimo et al., 1998; Basiotis and Lino, 2002), with 43% of Americans living below the poverty line lacking consistent access to sufficient food (Levine, 2011). Healthier foods, such as fresh vegetables and fruit, are more expensive, are perceived as luxury items and are unaffordable for many low-income consumers. Even when sufficient funds are available, people living in impoverished areas may have diminished access to fresh, healthy food ("food deserts") (Levine, 2011). A body of evidence has demonstrated an association between a sedentary lifestyle and poor health, obesity, metabolic syndrome, cardiovascular disease and premature death (Hamilton et al., 2007; Thorp et al., 2011). Differences in sedentariness appear to account for more than 50% of county-to-county variance in obesity in the United States, with the poorest counties showing the highest levels of sedentariness and obesity (Levine, 2011). The relatively low level of physical activity of people in poor counties may be explained by factors discouraging outdoor activities, such as a lack of sports facilities and parks (Hill and Peters, 1998) and unsafe neighbourhoods with higher levels of violence.

As lower-income countries develop economically, the prevalence of overweight increases significantly amongst the poorest, while remaining unchanged amongst the wealthiest. This increase in overweight in the poor has been predicted to affect approximately 70% of countries worldwide by 2040 (Templin et al., 2019). The relative poor may therefore shoulder the greatest health burden, requiring special targeting and planning for public health policies in order to avoid increasing

disparities and additional expenditure of health care systems. The growing prevalence of overweight and obesity in children and adolescents is of particular concern, since childhood obesity is associated with significant health and economic lifetime cost, especially in regard to the risk of non-communicable conditions in later life (Must et al., 1992; Sonntag et al., 2015a). Among the chief factors determining the growth of child obesity are obesogenic environments, which are the collective influences of opportunities, surroundings and conditions of life involving food and physical activity in homes and schools, on the promotion of obesity (Swinburn et al., 1999; Swinburn and Egger, 2002).

The food industry exerts an extensive influence on unhealthy diet-related behaviours and obesity in children and adolescents and has a significant impact on the creation of obesogenic environments. This influence encompasses promotional campaigns and the funding of exposure to commercial influences through mass media internet and television (Sonntag et al., 2015b). Television advertising (Jeffery and French, 1998; Wilson et al., 1999) and energy-dense food marketing (Nestle, 2002; 2003; Robinson, 1998) have been found to be factors contributing to increased consumption of foods high in energy, sugar and fat. Some of this advertising appears to be targeted especially at low-income consumers and children (Wilson et al., 1999). Numerous studies have demonstrated that the food industry influences children's preferences for its high-energy dense products (Sonntag et al., 2015b). Television advertising appears to have a stronger influence on the extent of food and beverage consumption of children from low-income families than those from high-income families (Buijzen et al., 2008). Public policy may be needed to create healthy food environments without interference from industry. Potential policy measures discouraging the overconsumption of unhealthy food and beverages include the raising of prices through taxation, such as an excise tax on the sugar content of soft drinks, which appears to be effective in reducing their consumption by children and adolescents (Fletcher et al., 2010; Bonnet and Réquillart, 2013). In short, the management of obesity and other non-communicable diseases can be effective only through policies adequately addressing the social determinants of health.

5. Future directions

As in Virchow's times, the reduction of poverty today would facilitate more informed choices and consequent disease prevention among sections of the population. The term "lifestyle choice" suggests that health could be maintained in individuals making more educated decisions concerning nutrition and physical activities as well as smoking and drinking habits. However, the choices of many people suffering the greatest effects of unhealthy lifestyles are often limited (Salisbury, 2020). Pressures created by job insecurity, low wages and exposure to obesogenic environments with ubiquitously available cheap sugar often make lifestyle changes and consequent improvement of health difficult. The concept of lifestyle choice

and the appeal to individual responsibility distracts from the necessity of policies addressing the disease-inducing societal, occupational and environmental structures. The present knowledge of the social, environmental, cultural, political and commercial determinants of health needs to be linked to specific policies and actions (Healthier Societies for Healthy Populations Group, 2020). Enabling people to remain healthy is important not only for the health of individuals, but also for the sustainable development of entire societies.

Global trends in regard to non-communicable diseases are associated with several key risk factors, including tobacco smoking and second-hand smoke exposure, hypertension, overweight and obesity, physical inactivity, alcohol use and diets low in fruits and vegetables and high in sodium and trans fats (Lee et al., 2012; Lim et al., 2012; Murray et al., 2012; Lange, 2017). The high prevalence of non-communicable diseases also contributes to the impact of COVID-19 (Kluge et al., 2020). Specific, effective and safe preventive and therapeutic measures against COVID-19, such as vaccines, antiviral agents and passive immunotherapy, are highly desirable. However, many problems in this context remain to be solved (Lange, 2020), and comprehensive and effective prevention and treatment may include changes in various lifestyle factors contributing to susceptibility to infection with the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and a severe course of COVID-19 (Lange and Nakamura, 2020a, 2020b). Psychological distress and confinement to the home due to the current COVID-19 pandemic may lead to harmful health behaviours, such as overeating, reduced physical activity, elevated alcohol and tobacco use and increased screen time causing impaired sleep. All of these behaviours are associated with non-communicable diseases and can also impair immunity. While no foods, single nutrients or dietary supplements are capable of preventing infection with COVID-19 (Lange and Nakamura, 2020c), a balanced diet containing sufficient amounts of macronutrients and diverse micronutrients is a prerequisite of an optimally functioning immune system (Lange, 2021c). Obesity has a substantial impact on pathogen defence and immunity, and a link has been demonstrated between obesity and various infectious diseases (Milner and Beck, 2012). Obesity has modulatory effects on populations of immune cells critical in the response to SARS-CoV-2 (van der Weerd et al., 2012) and is a major risk factor for COVID-19 (Kass et al., 2020; Lighter et al., 2020). Alcohol use (Szabo, 1997; de Roux et al., 2006; Rehm et al., 2009; Imtiaz et al., 2017) and tobacco smoking (O'Leary et al., 2014; van Zyl-Smit et al., 2014; Lawrence et al., 2019) are also known to have detrimental effects on the immune system. Therefore, population-wide body weight control, reduction of smoking rates and limitation of alcohol consumption are important preventive measures. Furthermore, sufficient restorative sleep is needed for adequate immune functioning (Bryant et al., 2004; Ibarra-Coronado et al., 2015; Irwin and Opp, 2017; Besedovsky et al., 2019). Appropriate lifestyle changes in regard to nutrition, exercise, sleep, smoking and alcohol intake may help shift the population distribution of infection risk and

aid in preventing severe COVID-19 disease (Lange and Nakamura, 2020a). Large-scale surveys should explore the effects of lifestyle changes, and the provision of reliable lifestyle information and effective interventions to individuals and communities during the pandemic is a pressing need.

Today, prevention is understood to be a mainstay of modern health care (Fani Marvasti and Stafford, 2012). According to the theory of the developmental origin of health and human disease (Barker, 1994; Penkler et al., 2019), a wide range of early interventions in many areas of medicine are needed (Schor, 2003). Preventive measures even before conception may be required, since, for example, the metabolic state and diets of parents can influence the risk of obesity for their children and grandchildren (Elshenawy and Simmons, 2016; Houfflyn et al., 2017). Various health problems may be best addressed by combining approaches of both clinical practice and public health. For example, the Million Hearts® initiative in the United States has the stated goal of preventing one million heart attacks and strokes within five years (Million Hearts, 2021). The clinical approaches of this initiative include increasing the use of anti-thrombotic agents in high-risk individuals as well as improving the control of blood pressure and management of cholesterol, while the public health approaches aim to decrease smoking and reduce the intake of sodium and artificial trans fats at population level. The available knowledge of the human immunodeficiency virus (HIV) shows how the combination of preventive measures and pharmacological interventions can be effective in ending the HIV epidemic (Fauci et al., 2019).

A sound information base on the long-term effectiveness and cost-effectiveness of population-wide preventive interventions and health promotion efforts is lacking. The absence of clear objectives and quantification of outcomes as well as the failure to take cost-effectiveness into consideration needs to be addressed (Wanless, 2004). In particular, a coordinated long-term strategy is required to replace the prevailing short-term target culture. Adequate prevention strategies implemented today, especially those targeting children and young adults, would enable the redistribution of resources needed for the therapy of chronic diseases in the future.

6. Concluding remarks

While the attention of health professionals and politicians worldwide is currently focused on the COVID-19 pandemic, previous health agendas, in particular those addressing the high prevalence of non-communicable diseases in higher-income regions of the world, remain important. The ever-increasing burden of chronic conditions in less wealthy countries is no less important. The prescribing of medications for non-communicable conditions is easier than addressing risk factors of chronic disease and exploring adequate lifestyle changes, which may be more difficult to achieve but also be potentially more effective. The key factors contributing to chronic disease are unhealthy lifestyles with high-calorie diets, a sedentary

lifestyle, insufficient physical exercise, tobacco smoking and alcohol use. All but those with vested interests would agree that preventing non-communicable diseases through weight control, physical exercise and avoidance of tobacco and alcohol would be preferable to treating related conditions with drugs or other therapies. Therefore, a global health priority should be the prevention and early detection of non-communicable diseases in order to reduce the future demand on healthcare systems. Comprehensive approaches reaching the entire population will be required to ensure that community environments promote and sustain behaviours and lifestyles that contribute most to health. Many countries worldwide have ageing populations and face an increase in the prevalence of age-related diseases and escalating healthcare costs. Interventions capable of slowing ageing and reducing the number of disability-adjusted life years may have greater benefit than those targeted at individual disease. If ageing could be combined with extended years of healthy life, this may not only improve individual and population health, but also produce numerous social and economic dividends.

The considerable body of evidence concerning factors promoting health and wellbeing and those causing harm to health needs to be adopted and implemented. Strategies devised to achieve the most effective and wide-ranging advances in disease prevention and health promotion should become priorities in national agendas and investment decisions. Both public demand and decisive leadership are required to motivate significant changes in health improvement. Governments must be held responsible and accountable for the collective right to health and to healthy places to live, move, work and play. Governments should be sensible of this responsibility, particularly those of the various countries that have responded and continue to respond very poorly to the present coronavirus pandemic, showing vacillation, obfuscation, dishonesty and incompetence.

Even the best medical research will be unable to improve society and enhance the common good as long as policymakers fail to rationally address the current health problems and, on the basis of scientific evidence, implement the necessary changes. The quality of health research must be evaluated independently of political expedience and vested interests. Science contrary to the political goals of those in power must not be ignored or discredited. Politics frequently operates on a timescale governed by elections and media attention and fails to consider the greater timescale at which population health and its determinants can be expected to change. Many politicians focus on re-election in the short term rather than the long-term welfare of the electorate. During the current COVID-19 crisis, many democratic systems stumbled and appeared to be less able than some autocracies to make the tough decisions required to get the pandemic under control. Governments should use their capacity to effect lasting and meaningful changes at population level, but many seem unwilling to tackle the increasing prevalence of potentially preventable, non-communicable diseases and to make needed policy decisions regarding sugar,

smoking, alcohol and a sedentary lifestyle. Perhaps global health advocates should have more influence on political agendas, with health in all policies as a long-term strategy. The current pandemics of infectious and non-communicable diseases require the spirit of Virchow and other medical reformers of 1848, who announced that their purpose was change, “not ... for the doctors’ but for the patients’ sake” (Ackerknecht, 1953).

Conflict of interest

The author declared no conflict of interest.

References

- Ackerknecht, E.H. (1953). *Rudolf Virchow: doctor, statesman, anthropologist*. Madison: University of Wisconsin Press.
- Alaimo, K., Briefel, R.R., Frongillo, E.A., and Olson, C.M. (1998). Food insufficiency exists in the United States: results from the third National Health and Nutrition Examination Survey (NHANES III). *Am. J. Public Health* 88, 419–426.
- Andree, C. (2002). *Rudolf Virchow: Leben und Ethos eines grossen Arztes*. München: Langen-Müller.
- Bagot, C.N., and Arya, R. (2008). Virchow and his triad: a question of attribution. *Br. J. Haematol.* 143, 180–190.
- Balkhausen, I. (2007). *Der Staat als Patient: Rudolf Virchow und die Erfindung der Sozialmedizin von 1848*. Marburg: Tectum-Verlag.
- Barker, D. (1994). The fetal origins of adult disease. *Fet. Matern. Med. Rev.* 6, 71–80.
- Basiotis, P.P., and Lino, M. (2002). Food insufficiency and prevalence of overweight among adult women. *Nutrition Insights* 26, 1–2.
- Berg, M.C., Jonsson, I., Conner, M.T., and Lissner, L. (2002). Relation between breakfast food choices and knowledge of dietary fat and fiber among Swedish schoolchildren. *J. Adolesc. Health* 31, 199–207.
- Besedovsky, L., Lange, T., and Haack, M. (2019). The sleep-immune crosstalk in health and disease. *Physiol. Rev.* 99, 1325–1380.
- Bonnet, C., and Réquillart, V. (2013). Tax incidence with strategic firms in the soft drink market. *J. Public Econ.* 106, 77–88.
- Bowman, S.A., Lino, M., Gerrior, S.A., and Basiotis, P.P. (1998). *The Healthy Eating Index: 1994-96*. Washington, DC: US Department of Agriculture.
- Bryant, P.A., Trinder, J., and Curtis, N. (2004). Sick and tired: Does sleep have a vital role in the immune system? *Nat. Rev. Immunol.* 4, 457–467.
- Buijzen, M., Schuurman, J., and Bomhof, E. (2008). Associations between children's television advertising exposure and their food consumption patterns: a household diary-survey study. *Appetite* 50, 231–239.
- Burke, E. (2009). *Reflections on the revolution in France*. Oxford world's classics. Oxford: Oxford University Press.
- Cavadini, C., Siega-Riz, A.M., and Popkin, B.M. (2000). US adolescent food intake trends from 1965 to 1996. *Arch. Dis. Child.* 83, 18–24.
- Centers for Medicare and Medicaid Services (2012). *Chronic Conditions among Medicare Beneficiaries, chartbook, 2012 edition*. Baltimore, MD.
- Chisholm, B. (1949). Social medicine. *Sci. Am.* 180, 11–15.
- Chopin, K. (1992). Pollution most foul. *BMJ* 304, 1495–1497.
- Elshenawy, S., and Simmons, R. (2016). Maternal obesity and prenatal programming. *Mol. Cell. Endocrinol.* 435, 2–6.
- Fani Marvasti, F., and Stafford, R.S. (2012). From sick care to health care--reengineering prevention into the U.S. system. *N. Engl. J. Med.* 367, 889–891.
- Fauci, A.S., Redfield, R.R., Sigounas, G., Weahkee, M.D., and Giroir, B.P. (2019). Ending the HIV epidemic: a plan for the United States. *JAMA* 321, 844–845.
- Flegal, K.M., Carroll, M.D., Ogden, C.L., and Johnson, C.L. (2002). Prevalence and trends in obesity among US adults, 1999-2000. *JAMA* 288, 1723–1727.
- Fletcher, J.M., Frisvold, D.E., and Tefft, N. (2010). The effects of soft drink taxes on child and adolescent consumption and weight outcomes. *J. Public Econ.* 94, 967–974.
- Garnier, R., Benetka, J.R., Kraemer, J., and Bansal, S. (2021). Socioeconomic disparities in social distancing during the COVID-19 pandemic in the United States: observational study. *J. Med. Internet Res.* 23, e24591.
- GBD 2016 DALYs and HALE Collaborators (2017). Global, regional, and national disability-adjusted life-years (DALYs) for 333 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet* 390, 1260–1344.
- Goschler, C. (2002). *Rudolf Virchow: Mediziner, Anthropologe, Politiker*. Köln: Böhlau.
- Hamilton, M.T., Hamilton, D.G., and Zderic, T.W. (2007). Role of low energy expenditure and sitting in obesity, metabolic syndrome, type 2 diabetes, and cardiovascular disease. *Diabetes* 56, 2655–2667.
- Harnack, L., Stang, J., and Story, M. (1999). Soft drink consumption among US children and adolescents: nutritional consequences. *J. Am. Diet. Assoc.* 99, 436–441.
- Hawkins, R.B., Charles, E.J., and Mehaffey, J.H. (2020). Socio-economic status and COVID-19-related cases and fatalities. *Public Health* 189, 129–134.
- Healthier Societies For Healthy Populations Group (2020). Healthier societies for healthy populations. *Lancet* 395, 1747–1749.
- Hill, J.O., and Peters, J.C. (1998). Environmental contributions to the obesity epidemic. *Science* 280, 1371–1374.
- Houffly, S., Matthys, C., and Soubry, A. (2017). Male obesity: epigenetic origin and effects in sperm and offspring. *Curr. Mol. Biol. Rep.* 3, 288–296.
- Hoyert, D.L., and Xu, J. (2012). Deaths: preliminary data for 2011. *Natl. Vital Stat. Rep.* 61, 1–51.
- Ibarra-Coronado, E.G., Pantaleón-Martínez, A.M., Velazquez-Moctezuma, J., Prospéro-García, O., Méndez-Díaz, M., Pérez-Tapia, M., Pavón, L., and Morales-Montor, J. (2015). The bidirectional relationship between sleep and immunity against infections. *J. Immunol. Res.* 2015, 678164.
- Imtiaz, S., Shield, K.D., Roerecke, M., Samokhvalov, A.V., Lönnroth, K., and Rehm, J. (2017). Alcohol consumption as a risk factor for tuberculosis: meta-analyses and burden of disease. *Eur. Respir. J.* 50.
- Irwin, M.R., and Opp, M.R. (2017). Sleep health: reciprocal regulation of sleep and innate immunity. *Neuropsychopharmacology* 42, 129–155.
- James, W.P.T. (2008). The epidemiology of obesity: the size of the problem. *J. Intern. Med.* 263, 336–352.
- Jeffery, R.W., and French, S.A. (1998). Epidemic obesity in the United States: are fast foods and television viewing contributing? *Am. J. Public Health* 88, 277–280.
- Kant, A.K. (2000). Consumption of energy-dense, nutrient-poor foods by adult Americans: nutritional and health implications. The third National Health and Nutrition Examination Survey, 1988-1994. *Am. J. Clin. Nutr.* 72, 929–936.
- Karmakar, M., Lantz, P.M., and Tipirneni, R. (2021). Association of social and demographic factors with COVID-19 incidence and death rates in the US. *JAMA Netw. Open* 4, e2036462.
- Kass, D.A., Duggal, P., and Cingolani, O. (2020). Obesity could shift severe COVID-19 disease to younger ages. *Lancet* 395, 1544–1545.
- Kluge, H.H.P., Wickramasinghe, K., Rippin, H.L., Mendes, R., Peters, D.H., Kontsevaya, A., and Breda, J. (2020). Prevention and control of non-communicable diseases in the COVID-19 response. *Lancet* 395, 1678–1680.
- Krech, R. (2011). Social determinants of health: practical solutions to deal with a well-recognized issue. *Bull. World Health Organ.* 89, 703.
- Lange, K.W. (2017). Trans fats or the translation of scientific evidence into political action. *Mov. Nutr. Health Dis.* 26–30.
- Lange, K.W. (2020). The prevention of COVID-19 and the need for reliable data. *Mov. Nutr. Health Dis.* 4, 53–63.
- Lange, K.W. (2021a). Celebrating public health lives: Rudolf Virchow. *Public Health* 198, 290–291.
- Lange, K.W. (2021b). Rudolf Virchow, poverty and global health: from “politics as medicine on a grand scale” to “health in all policies”. *Glob. Health J.* 5, 149–154.
- Lange, K.W. (2021c). Food science and COVID-19. *Food Sci. Hum. Wellness* 10, 1–5.
- Lange, K.W., and Nakamura, Y. (2020a). Lifestyle factors in the prevention of COVID-19. *Glob. Health J.* 4, 146–152.
- Lange, K.W., and Nakamura, Y. (2020b). Movement and nutrition in COVID-19. *Mov. Nutr. Health Dis.* 89–94.
- Lange, K.W., and Nakamura, Y. (2020c). Food bioactives, micronutrients, immune function and COVID-19. *J. Food Bioact.* 10, 1–8.
- Lawrence, H., Hunter, A., Murray, R., Lim, W.S., and McKeever, T. (2019). Cigarette smoking and the occurrence of influenza - systematic review. *J. Infect.* 79, 401–406.
- Lee, I.-M., Shiroma, E.J., Lobelo, F., Puska, P., Blair, S.N., and Katzmarzyk, P.T. (2012). Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet* 380, 219–229.

- Levine, J.A. (2011). Poverty and obesity in the U.S. *Diabetes* 60, 2667–2668.
- Lighter, J., Phillips, M., Hochman, S., Sterling, S., Johnson, D., Francois, F., and Stachel, A. (2020). Obesity in patients younger than 60 years is a risk factor for COVID-19 hospital admission. *Clin. Infect. Dis.* 71, 896–897.
- Lim, S.S., Vos, T., Flaxman, A.D., Danaei, G., Shibuya, K., Adair-Rohani, H., AlMazroa, M.A., Amann, M., Anderson, H.R., Andrews, K.G., Aryee, M., Atkinson, C., et al. (2012). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 380, 2224–2260.
- Lönnroth, K., Jaramillo, E., Williams, B., Dye, C., and Raviglione, M. (2010). Tuberculosis: the role of risk factors and social determinants. In: Blas, E., Sivasankara Kurup, A. (eds.). *Equity, social determinants and public health programmes*. World Health Organisation. pp 219–242.
- Low, S., Chin, M.C., and Deurenberg-Yap, M. (2009). Review on epidemic of obesity. *Ann. Acad. Med. Singap.* 38, 57–59.
- Ludwig, D.S., Peterson, K.E., and Gortmaker, S.L. (2001). Relation between consumption of sugar-sweetened drinks and childhood obesity: a prospective, observational analysis. *Lancet* 357, 505–508.
- Mackenbach, J.P. (2009). Politics is nothing but medicine at a larger scale: reflections on public health's biggest idea. *J. Epidemiol. Community Health* 63, 181–184.
- Malkin, H.M. (1990). Rudolf Virchow and the durability of cellular pathology. *Perspect. Biol. Med.* 33, 431–443.
- McNeely, I.F. (2002). "Medicine on a grand scale": Rudolf Virchow, liberalism, and the public health. London: Wellcome Trust.
- Mena, G.E., Martinez, P.P., Mahmud, A.S., Marquet, P.A., Buckee, C.O., and Santillana, M. (2021). Socioeconomic status determines COVID-19 incidence and related mortality in Santiago, Chile. *Science* 372, eabg5298.
- Million Hearts (2021). <https://millionhearts.hhs.gov/>. Accessed October 10, 2021.
- Milner, J.J., and Beck, M.A. (2012). The impact of obesity on the immune response to infection. *Proc. Nutr. Soc.* 71, 298–306.
- Misra, A., and Khurana, L. (2008). Obesity and the metabolic syndrome in developing countries. *J. Clin. Endocrinol. Metab.* 93, S9–S30.
- Murray, C.J.L., Vos, T., Lozano, R., Naghavi, M., Flaxman, A.D., Michaud, C., Ezzati, M., Shibuya, K., Salomon, J.A., Abdalla, S., Aboyans, V., Abraham, J., et al. (2012). Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 380, 2197–2223.
- Must, A., Jacques, P.F., Dallal, G.E., Bajema, C.J., and Dietz, W.H. (1992). Long-term morbidity and mortality of overweight adolescents. a follow-up of the Harvard Growth Study of 1922 to 1935. *N. Engl. J. Med.* 327, 1350–1355.
- Negri, F. de, Galiezz, R., Miranda, P., Koeller, P., Zucoloto, G., Costa, J., Farias, C.M., Travassos, G.H., and Medronho, R.A. (2021). Socioeconomic factors and the probability of death by Covid-19 in Brazil. *J. Public Health*, 493–498.
- Nestle, M. (2002). *Food politics: How the food industry influences nutrition and health*. California studies in food and culture 3. Berkeley, CA: University of California Press.
- Nestle, M. (2003). The ironic politics of obesity. *Science* 299, 781.
- Nielsen, S.J., Siega-Riz, A.M., and Popkin, B.M. (2002). Trends in energy intake in U.S. between 1977 and 1996: similar shifts seen across age groups. *Obes. Res.* 10, 370–378.
- O'Leary, S.M., Coleman, M.M., Chew, W.M., Morrow, C., McLaughlin, A.M., Gleeson, L.E., O'Sullivan, M.P., and Keane, J. (2014). Cigarette smoking impairs human pulmonary immunity to *Mycobacterium tuberculosis*. *Am. J. Respir. Crit. Care Med.* 190, 1430–1436.
- Patterson, R.E., Kristal, A.R., and White, E. (1996). Do beliefs, knowledge, and perceived norms about diet and cancer predict dietary change? *Am. J. Public Health* 86, 1394–1400.
- Penkler, M., Hanson, M., Biesma, R., and Müller, R. (2019). DOHaD in science and society: emergent opportunities and novel responsibilities. *J. Dev. Orig. Health Dis.* 10, 268–273.
- Putnam, J., Allshouse, J., and Kantor, L.S. (2002). U.S. Per capita food supply trends: more calories, refined carbohydrates, and fats. *Food Rev.* 25, 2–15.
- Quan, T., Salomon, J., Nitzke, S., and Reicks, M. (2000). Behaviors of low-income mothers related to fruit and vegetable consumption. *J. Am. Diet. Assoc.* 100, 567–570.
- Ramakrishnan, C.V., Rajendran, K., Jacob, P.G., Fox, W., and Radhakrishna, S. (1961). The role of diet in the treatment of pulmonary tuberculosis. An evaluation in a controlled chemotherapy study in home and sanatorium patients in South India. *Bull. World Health Organ.* 25, 339–359.
- Raoult, D., Ndiokubwayo, J.B., Tissot-Dupont, H., Roux, V., Faugere, B., Abegbinni, R., and Birtles, R.J. (1998). Outbreak of epidemic typhus associated with trench fever in Burundi. *Lancet* 352, 353–358.
- Raviglione, M., and Krech, R. (2011). Tuberculosis: still a social disease. *Int. J. Tuberc. Lung. Dis.* 15 Suppl 2, 6–8.
- Rehm, J., Samokhvalov, A.V., Neuman, M.G., Room, R., Parry, C., Lönnroth, K., Patra, J., Poznyak, V., and Popova, S. (2009). The association between alcohol use, alcohol use disorders and tuberculosis (TB). A systematic review. *BMC Public Health* 9, 450.
- Reicks, M., Randall, J.L., and Haynes, B.J. (1994). Factors affecting consumption of fruits and vegetables by low-income families. *J. Am. Diet. Assoc.* 94, 1309–1311.
- Robinson, T.N. (1998). Does television cause childhood obesity? *JAMA* 279, 959–960.
- Rocha, R., Atun, R., Massuda, A., Rache, B., Spinola, P., Nunes, L., Lago, M., and Castro, M.C. (2021). Effect of socioeconomic inequalities and vulnerabilities on health-system preparedness and response to COVID-19 in Brazil: a comprehensive analysis. *Lancet Glob. Health* 9, e782–e792.
- Rosen, G. (1947). What is social medicine? a genetic analysis of the concept. *Bull. Hist. Med.* 21, 674–733.
- Roux, A. de, Cavalcanti, M., Marcos, M.A., Garcia, E., Ewig, S., Mensa, J., and Torres, A. (2006). Impact of alcohol abuse in the etiology and severity of community-acquired pneumonia. *Chest* 129, 1219–1225.
- Salisbury, H. (2020). Helen Salisbury: Is lifestyle a choice? *BMJ* 370, m2701.
- Schoenborn, C.A., Adams, P.F., and Barnes, P.M. (2002). Body weight status of adults: United States, 1997–98. *Adv. Data*, 1–15.
- Schor, E.L. (2003). Family pediatrics: report of the Task Force on the Family. *Pediatrics* 111, 1541–1571.
- Sonntag, D., Ali, S., Lehnert, T., Konnopka, A., Riedel-Heller, S., and König, H.-H. (2015a). Estimating the lifetime cost of childhood obesity in Germany: results of a Markov Model. *Pediatr. Obes.* 10, 416–422.
- Sonntag, D., Schneider, S., Mdege, N., Ali, S., and Schmidt, B. (2015b). Beyond food promotion: a systematic review on the influence of the food industry on obesity-related dietary behaviour among children. *Nutrients* 7, 8565–8576.
- Southern, P.M., and Sanford, J.P. (1969). Relapsing fever: a clinical and microbiological review. *Medicine (Baltimore)* 48, 129–149.
- Sudhoff, K. (1922). *Virchow und die deutschen Naturforscherversammlungen*. Leipzig: Akademische Verlaganstalt.
- Swinburn, B., and Egger, G. (2002). Preventive strategies against weight gain and obesity. *Obes. Rev.* 3, 289–301.
- Swinburn, B., Egger, G., and Raza, F. (1999). Dissecting obesogenic environments: the development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Prev. Med.* 29, 563–570.
- Szabo, G. (1997). Alcohol's contribution to compromised immunity. *Alcohol Health Res. World* 21, 30–41.
- Templin, T., Cravo Oliveira Hashiguchi, T., Thomson, B., Dieleman, J., and Bendavid, E. (2019). The overweight and obesity transition from the wealthy to the poor in low- and middle-income countries: a survey of household data from 103 countries. *PLoS Med.* 16, e1002968.
- Tepper, B.J., Choi, Y.-S., and Nayga, R.M. (1997). Understanding food choice in adult men: Influence of nutrition knowledge, food beliefs and dietary restraint. *Food Qual. Prefer.* 8, 307–317.
- Thorp, A.A., Owen, N., Neuhaus, M., and Dunstan, D.W. (2011). Sedentary behaviors and subsequent health outcomes in adults: a systematic review of longitudinal studies, 1996–2011. *Am. J. Prev. Med.* 41, 207–215.
- U.S. Department of Health and Human Services (2000). *Office of Disease Prevention and Health Promotion—Healthy People 2010*. *Nasnewsletter* 15, 3.
- United Health Foundation (2012). *America's Health Rankings. A call to action for individuals and their communities*. 2012 edition.
- van der Weerd, K., Dik, W.A., Schrijver, B., Schweitzer, D.H., Langerak, A.W., Drexhage, H.A., Kiewiet, R.M., van Aken, M.O., van Huisstede, A., van Dongen, J.J.M., van der Lelij, A.-J., Staal, F.J.T., et al. (2012). Morbidly obese human subjects have increased peripheral blood CD4+ T cells with skewing toward a Treg- and Th2-dominated phenotype. *Diabetes* 61, 401–408.
- van Zyl-Smit, R.N., Binder, A., Meldau, R., Semple, P.L., Evans, A., Smith, P., Bateman, E.D., and Dheda, K. (2014). Cigarette smoke impairs cytokine responses and BCG containment in alveolar macrophages. *Thorax* 69, 363–370.
- Virchow, R. (1848). *Mittheilungen über die in Oberschlesien herrschende Typhus-Epidemie*. Berlin: G. Reimer.

- Virchow, R. (1863-1867). *Die krankhaften Geschwülste*, Vol. 1–3. Berlin: Hirschwald.
- Virchow, R. (1879). *Virchow, Rudolf: Gesammelte Abhandlungen aus dem Gebiete der öffentlichen Medicin und der Seuchenlehre*. Berlin: Hirschwald.
- Virchow, R. (1978). *Cellular pathology*. Classics of medicine library. Omaha, NE: Gryphon Editions.
- Virchow, R. (1985). *Collected essays on public health and epidemiology*, Vol. 1. Rather, L.J. (ed.). Canton, MA: Science History Publications.
- Wachtler, B., Michalski, N., Nowossadeck, E., Diercke, M., Wahrendorf, M., Santos-Hövenner, C., Lampert, T., and Hoebel, J. (2020). Socioeconomic inequalities and COVID-19 – a review of the current international literature. *J. Health Monit.*, e1–e12.
- Waitzkin, H. (1981). The social origins of illness: a neglected history. *Int. J. Health Serv.* 11, 77–103.
- Wang, L., Kong, L., Wu, F., Bai, Y., and Burton, R. (2005). Preventing chronic diseases in China. *Lancet* 366, 1821–1824.
- Wanless, D. (2004). *Securing good health for the whole population*. Norwich: Her Majesty's Stationery Office.
- Ward, B.W., and Schiller, J.S. (2013). Prevalence of multiple chronic conditions among US adults: estimates from the National Health Interview Survey, 2010. *Prev. Chronic Dis.* 10, E65.
- Wilson, N., Quigley, R., and Mansoor, O. (1999). Food ads on TV: a health hazard for children? *Aust. N. Z. J. Public Health* 23, 647–650.
- World Bank and World Health Organisation (2017). *Tracking Universal Health Coverage: 2017 Global Monitoring Report*. Washington, DC: World Health Organisation.
- World Health Organisation (2000). *Obesity: Preventing and managing the global epidemic*. WHO technical report series 894. Geneva: World Health Organisation.
- World Health Organisation (2018). *Global health estimates 2016: deaths by cause, age, sex, by country and by region, 2000–2016*. Geneva: World Health Organisation.
- World Health Organisation (2020). *Obesity and overweight*. Accessed Oct 10, 2021. <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>.
- Yach, D., Hawkes, C., Gould, C.L., and Hofman, K.J. (2004). The global burden of chronic diseases: overcoming impediments to prevention and control. *JAMA* 291, 2616–2622.
- Zizza, C., Siega-Riz, A.M., and Popkin, B.M. (2001). Significant increase in young adults' snacking between 1977-1978 and 1994-1996 represents a cause for concern! *Prev. Med.* 32, 303–310.