



It's time to take a sustainable approach to health care in the face of the challenges of the 21st century



Catherine Laprise ^{a,b,c,*}

^a Centre Intersectoriel en Santé Durable, Université du Québec à Chicoutimi, Saguenay, QC G7H 2B1, Canada

^b Département des Sciences Fondamentales, Université du Québec à Chicoutimi, Saguenay, QC G7H 2B1, Canada

^c Centre Intégré Universitaire en Santé et Services Sociaux du Saguenay–Lac-Saint-Jean, Saguenay, QC G7H 7K9, Canada

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ABSTRACT

Health challenges in the 21st century have become increasingly complex and global. The recent COVID-19 pandemic has only exacerbated the many problems faced by health care systems around the world and sadly, exposed various flaws. With ageing populations, particularly in Canada, as well as unavoidable factors such as globalization and accelerating climate change, it is becoming imperative to implement a new health care approach based on intersectorality and interdisciplinarity. Furthermore, links must be forged between all the stakeholders, i.e. the researchers, the health system and its specialists, the communities and the individuals themselves. It is in this perspective, where everyone concerned must be equally involved in attaining a better quality of life, that the concepts of One Health and sustainable health must be deployed.

1. Context

Health issues are increasingly complex, especially in the context of climate change, requiring serious and profound reflection on the way healthcare is provided by professionals. There is a growing number of people living with multimorbidity issues and such conditions require interdisciplinary approaches, which compel professionals to change the way they provide care. Furthermore, healthcare systems were not initially designed to support this type of patient follow-up. Major health challenges such as global child development, adopting healthier life habits, the burden of chronic diseases as well as mental health issues are all complex and multifactorial, and do not relate to a single discipline. It is now recognized that human health is closely linked to the environment. Consequently, factors such as population demographics, major environmental events and migration all influence the frequency and severity of communicable and non-communicable diseases in a different way all around the world. It is time to modify our perception of what health is, in order to have a more global perspective while addressing as many influencing factors as possible, if we want to maintain the health and well-being for all during their life-course or, in other words, fostering Sustainable Health (SH). Before defining SH, we must ascertain the concept of "health", which is no simple task. The definition of health

has evolved over the past decades, going from a "mechanical" model at first, to a more holistic one. The global concept of health now incorporates both mental and social elements and takes into account a person's desires, as well as his/her level of adaptability, to change and his/her social environment. The World Health Organization (WHO) defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". Based on this definition and the one of Alliance Santé Québec [1], researchers at UQAC's *Centre intersectoriel en santé durable (CISD)* de l'Université du Québec à Chicoutimi (UQAC) define the concept of SH as follows:

A state of physical, psychological and social well-being, maintained throughout life, which evolves in environments enriched with quality human and material resources, by ensuring social and gender fairness for all populations, including the one in vulnerable situation, and for future generations.¹

The aim of this paper is to draw a broader picture, by addressing how the context we live in (including human health challenges, ageing population, globalization and environment) directly affects people's health all around the world, more specifically the Canadian population, and to propose an integrative approach to rethink health care and research so we can respond better. It will also serve to demonstrate the

* Corresponding author at : Département des Sciences Fondamentales, Université du Québec à Chicoutimi, Saguenay, Québec G7H 2B1, Canada.

E-mail address: catherine.laprise@uqac.ca.

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potential for interdisciplinary and intersectoral exchanges and partnerships between research and community (e.g., hospitals, school boards, community organizations, etc.) in rural areas, where the population is usually scattered. These collaborations should result in research projects that are adaptable, flexible, focused on the real needs of communities concerned and could be implemented in other sectors.

2. Targeted key human health issues

2.1. Ageing population

Global human population is increasing, so is life expectancy. According to the WHO, the number of people aged 60 years and older will be 34% higher at the end of the present decade [2]. In Canada, the number of people aged over 65 years old exceeded the number of children (under 14-year-old) for the first time in 2016, and this should be in steady progression up until 2068 [3]. With ageing, the prevalence of multimorbidity increases significantly [4]. The definition of multimorbidity (presence of 2 or 3 chronic conditions and more) and the list of chronic conditions included in the definition (9 to 27 conditions) vary across studies, leading to a significant variation of multimorbidity prevalence found in the literature. Prevalence found in the Canadian population (18 years and older) varies from 12.9% (list of 9 chronic conditions; ≥ 2 conditions) [5] to 36.1% in Alberta (list of 16 chronic conditions; ≥ 2 conditions) to 63.8% in Quebec (list of 21 chronic conditions; ≥ 2 conditions) [6], while the prevalence for middle-aged Canadians (45–64 years) found by Sakib et al. [7] was 39.6% (list of 27 chronic conditions; ≥ 3 conditions). Despite variance in prevalence documented across studies, they generally concluded that multimorbidity increases with age, lower incomes and less education [5,7,8]. Also, the number of chronic disease cases would be higher among people with obesity (defined as a body mass index $\geq 30 \text{ kg/m}^2$) [8]. Thus, prevalence of multimorbidity increases with age, but a significant proportion of middle-aged Canadians also presents with multiple chronic conditions. The burden of multimorbidity that plagues health services, due to the overuse of these very services, great need for qualified professionals, polypharmacy and so on, risks getting worse in the context of ageing populations and the rise of multimorbidity cases hitting young people.

Thus, the ageing of the Canadian population is undeniable. Canada has a number of citizens over 65, representing close to 20% of its entire population [10]. Comparatively, the Saguenay–Lac-Saint-Jean region holds even higher data regarding this segment of the population representing close to 25% of the community [11]. In both cases, the segment of the population over 65 far exceeds the proportion of people of 19 years of age and under [10,11]. It is worth noting that the natural increase has been steadily declining since 2010.

As mentioned earlier, another risk associated with multimorbidity is polypharmacy, which relates to the use of multiple concomitant medications. In 2016, about two thirds of adult Canadians, aged over 65 years, received 5+ prescription medications and $>25\%$ had 10+ medications [4]. Polypharmacy can lead to potential adverse drug events, hospital admissions, reduction in patients' functional capacity leading to further impairment of quality of life, falls, cognitive impairment, and mortality [9,12–17]. Polypharmacy can also lead to non-adherence to treatment [18] and, consequently, to detrimental consequences on health. Also associated with polypharmacy is the prescription of inappropriate medications, such as incorrect dosing or potential interactions between medications including herbal and home remedies [18–20]. This phenomenon is particularly present in older people and individuals with mental health disorders. In Canada, the proportion of elderly people in 2016 taking potentially inappropriate drugs (according to the 2015 Beers list [19]) was 49.4% [20]. In 2013, total direct costs associated with potentially inappropriate prescribing among the seniors population of Canada was estimated at \$419 million, an amount reaching \$1.4 billion in total indirect health care costs [21]. One way to address this

issue is by deprescribing, i.e., "the process of withdrawal of an inappropriate medication, supervised by a health care professional with the goal of managing polypharmacy and improving outcomes" [22]. Although this process has shown evidence in improving health outcomes, such as mortality and falls [23], about 25% of caregivers are not willing to deprescribe [24].

In an attempt to reduce the negative consequences linked to the ageing population, the United Nations has declared 2021–2030 the Decade of Healthy Ageing [2]. According to the WHO, healthy ageing means that people must maintain their ability to meet their basic needs, learn, grow and make decisions, be mobile, build and maintain relationships and contribute to society [25]. Many factors beyond genetics can influence the way people age such as sex, ethnicity, environment and personal characteristics. To favor healthy ageing, people must be able to maintain healthy behaviors throughout life and live in supportive physical and social environments. Health care systems are not prepared for this kind of increase in numbers of older people, who often live with multiple health conditions such as heart disease, sensory impairments, back pain, chronic obstructive pulmonary diseases, depressive disorders and diabetes. Health care systems must adapt in order to focus on maintaining capacities of older people rather than put their efforts only in treating diseases. But at the same time, working on maintaining capacities of older people implies gathering the medical sector, leaders from neighbouring municipalities, governments as well as citizens to create a community favoring healthy behaviors, which include offering services that are accessible to all, regardless of their age, economic status or any other factors of vulnerability.

2.2. Globalization

If the COVID-19 pandemic has taught us anything, is that our world is becoming smaller by the day. What seemed to be a trivial infection at first, far from North American borders, eventually spread rapidly all around the world through people traveling for business or pleasure at an impressive rate, giving new sense to the One World One Health concept introduced in 2004 by the Wildlife Conservation Society. As of September 12th, 2022, there have been 4,23 M recorded cases of COVID-19 diagnosed in Canada, of which 44,607 resulted in death [26]. Globally, the death toll rose to an all-time high with 609 M confirmed cases and 6,51 M deaths [27]. Even though, experts and scientists rang the alarm several times on the possibility of a pandemic in the years preceding the COVID-19 crisis, our society and very few health care systems around the world were ready to grapple with the COVID-19 pandemic.

Globalization implies that there is a significant increase in population movement, including a surge in international migration flows. Reasons for which people migrate are various: forced (conflict- and disaster-induced), labour, family, international students and environmental, among others [28]. The recent conflict in Ukraine has already impacted its neighbouring countries with 5.2 million (as of July 9th) refugees having fled their home to seek asylum. The number of new migrants who entered one of the nations comprised in the G20, drastically decreased in 2020 (a 40% decrease compared to 2019) mainly due to COVID-19 travel restriction measures. Nevertheless, it represents a staggering amount of about 7 to 7.5 million people [29,30]. It also puts excessive pressure on healthcare systems in the neighbouring countries that are welcoming large influx of refugees. It comes with various challenges linked to access, quality of services, logistics and types of care available (see review [31]). No matter what the reason why they moved, migrants are often left in extremely vulnerable situations, with no social protection nor access to health care. They most likely be living in an inadequate housing and sadly, are often confronted with racism, xenophobia, discrimination, etc. And things won't get any better soon, considering the impact that climate change has on the frequency and severity of natural disasters and the labour market demands. Actions must be taken to provide safety and healthy conditions for the

population.

Globalization has also changed the way food circulates, facilitating access to fat, added sugar and animal food products, ultimately increasing their consumption as a result [32]. Availability and affordability of processed foods also increased in all parts of the world [33]. In addition, acceptable healthier diets are generally more expensive, all of which contribute to socioeconomic disparities in diet quality [34]. Along with a decrease in physical activities, this change in eating habits is accompanied by an increase in obesity, which is a major risk factor of cardiovascular diseases, diabetes, musculoskeletal disorders and some cancers [35]. Obesity is on the rise worldwide which is particularly worrying; a study published in *The Lancet* reported that the prevalence of obesity surpassed that of underweight in 2004 for women and in 2011 in men [36]. From 1975 to 2014, prevalence of underweight decreased from 13.8% to 8.8% in men and from 14.6% to 9.7% in women. Regarding the prevalence of obesity, it increased by a larger amount over the same period—from 3.2% in 1975 to 10.8% in 2014 in men, and from 6.4% to 14.9% in women [36]. In Canada, 26.8% of people aged 18 and older were clinically classified as obese in 2018, and 36.3% as overweight [37]. Regarding diabetes, 7.1% of Canadians aged 12 and over were diagnosed with Type 1 or Type 2 diabetes in 2020 [38]. Most type 2 diabetes diagnosed in adults (90–95%) are obesity-associated [39] and diabetes and insulin resistance are predictors of cardiovascular morbidity and mortality [40]. Krueger et al. estimated the annual economic burden of overweight and obesity in Canada to be CAD\$23.3 billion in 2012 [41].

As a whole, globalization would also have positive impacts on health status. A study conducted in 2019 by Jani et al. [42] showed that the economic globalization would contribute to reducing infant mortality rate and increase life expectancy, even in least developed countries. They also pointed out that all countries would benefit from globalization, but at a different rate and through different mechanisms. In high-income countries, the social dimension of globalization (e.g., access to better education and infrastructure) is the main factor influencing a positive impact, while economic and political dimensions are the main influencing elements for low-income countries (e.g., economic globalization allows a country getting proper infrastructure in order to give access to primary healthcare). Deaton (2003) rather argued that global health improvement does not stand on economic growth, but on the increase of knowledge transfers and health technologies between high- and low-income countries [43]. However, although there is an increasing information flows, leading theoretically to better access to health knowledge for more people, there is unequal access to this very knowledge across countries: only 20% of the population in low-income countries have access to the Internet, compared to 80% in high-income countries [44]. But, no matter the positive or negative impacts of globalization on health, it is not socially nor ecologically sustainable to continue growing incomes in the way we are doing now since our economy is based on the two factors that mostly influenced climate change: energy production/consumption and transportation [45].

2.3. Environment health

The environment we live in plays an important role in maintaining good health. There is growing evidence of a correlation between ecosystems degradation, urbanization and non-communicable diseases [46]. A review conducted by Twohig-Bennett and Jones in 2018 [47] documents the benefits of greenspace on a wide range of health outcomes: decreased salivary cortisol, heart rate, diastolic blood pressure, HDL cholesterol, low frequency heart rate variability and increased high frequency heart rate variability, as well as decreased risk of preterm birth, type II diabetes, all-cause mortality, small size for gestational age, cardiovascular mortality, an increased incidence of good self-reported health, and finally a reduced incidence of stroke, hypertension, dyslipidaemia, asthma and coronary heart disease.

Exposure to greenness would be associated with the prevalence of

asthmatic symptoms in schoolchildren [48] and may be protective of asthma and allergic diseases [49–54]. One of the studied avenues that would explain these associations is the role that could be played by environmental microbiomes (including animals, air, plants, soil and water microbiomes) in human health [55,56], in addition to supporting the development and regulation of the human immune system [56,57]. Exposure to a wide diversity of microbial communities could benefit immune development, which is called the biodiversity hypothesis [55,58–60]. Although there are remaining knowledge gaps in regards to the exact mechanistic pathways between urbanization, altered aerobiomes and human health [61], the biodiversity of air and human microbiomes in cities is becoming more homogeneous [52,61–65], and the prevalence of allergies, asthma and other immune dysfunction diseases is higher in urban areas [66]. Considering the constant increase of people living in such areas, there is an urgent need to act. Indeed, the number of people living in urban areas worldwide has surpassed those living in rural areas in 2007, for a total urban population of 4.35 billion people and 3.40 billion in rural population as of 2020. In Canada, the urban population rose from 12.37 million in 1960 to 31 million in 2020 (an increase of 151%), while the rise in rural population was only from 5.54 million to 7.01 million (an increase of 26%) [67].

Contact with nature is also associated with positive benefits on mental health for children [68–70], adolescents [71,72], adults [73,74] and older adults [75,76]. Results of a literature review highlighted that access to green space would be important for mental well-being, overall health as well as cognitive development of children, by promoting attention to restoration, moderating the impacts of stress, and improving behaviors and symptoms of attention-deficit/hyperactivity disorder [77]. In addition, there is some evidence suggesting a positive effect on later life mental health outcomes of early nature exposure [78]. A meta-analysis conducted in 2019 has shown a significant inverse association between surrounding greenness and all-cause mortality in adults [79]. As for Yuan et al. (2021) [80] who performed a literature review and meta-analysis in elderly people, they also found an association between stroke mortality and major cardiovascular disease events.

2.4. Air pollution

Air pollution originates from both natural and anthropogenic sources, but the latter being more important since industrialization began. The combustion of fossil fuels and biomass generating energy is mainly responsible for the increase of anthropic air pollutants, for which spatial distribution and concentration vary according to temporal factors (week VS week-end), spatial distribution of sources of pollutants, nature of pollutants and meteorological conditions [81]. In 2019, 90% of the global population lived in an environment where concentration of small particle matters (aerodynamic diameter $\leq 2.5 \mu\text{m}$) exceeded the 2005 WHO air quality guideline of $10 \mu\text{g}/\text{m}^3$ [81]. There is growing evidence showing the relationship between air pollution exposure and adverse health effects. WHO estimates at around 7 million the number of annual deaths attributable to the effects of ambient and household air pollution [82]. In Canada, the number of premature deaths per year was estimated at 15,300 in 2016, with a cost estimated at \$114 billion per year [83]. In 2019, the Global Burden of Diseases (GBD) documented the magnitude of risk factor exposure, relative risk and attributable burden of the disease [84]. The GBD produced a comprehensive assessment for 87 risk factors for 204 countries and territories. According to their results, air pollution is the fourth leading risk factor, accounting for 11.3% of all female deaths and 12.2% of all male deaths [84]. However, as for other risk factors of adverse health effects, inequities exist, linked to air pollution exposure on a global scale: an important improvement of air quality occurs in high-income countries while in comparison, unprecedented deterioration occurs in low- and middle-income countries [81]. Also, the leading risk factors of attributable deaths shift from malnutrition, air pollution, and water, sanitation, and handwashing in the low sociodemographic index to tobacco, high systolic blood pressure,

dietary risks, high body mass index, and high fasting plasma glucose [84]. Interventions to improve health outcomes must take into account characteristics of the population and pay special attention to vulnerable populations.

2.5. Climate change

It is undeniable that the world's climate is changing: frequency and intensity of extreme weather events is on the rise (such as longer and more frequent heat waves), the global mean temperature has increased by 1.1 °C since 1850–1990. In its last report, the Intergovernmental Panel on Climate Change (IPCC) highlighted unprecedented and even irreversible changes occurring as the consequence of human activity and production of greenhouse gases. Amid extreme weather and climate events, the IPCC noted that hot extremes and heatwaves are more intense and, at the opposite, cold extremes and cold waves are less severe [85]. An increase in the frequency and intensity of heavy precipitations as well as a decrease in monsoon rains have also been observed. Finally, human-induced climate change will likely influence the occurrence of major tropical cyclones and increase chances of compound extreme events [85]. All these events have the potential to impact not only the environment, flora and fauna, but human health as well.

A synthesis of systematic reviews published before June 22nd 2019 reports that most studies found an impact of climate change on different health outcomes [86]. Consequences of climate change were categorized into five groups: 1) meteorological (e.g., temperature, heat waves, humidity, precipitation, sunlight, wind, air pressure), 2) extreme weather (e.g., water-related, floods, cyclones, hurricanes, drought), 3) air quality (e.g., air pollution and wildfire smoke exposure), 4) general, and 5) other.

Scientific publications dealing with the general impacts of climate on health did not include climate change but rather focused on a more general approach. Some other publications dealt with climate change or more general environmental risks such as contaminants, sanitary measures and access to drinking water (e.g., environmental hazards, sanitation and access to clean water) [86].

All of these factors are impacting on one or the other of these health outcomes: vector-borne infectious diseases (e.g., dengue, malaria, Lyme, Zika); food and water-borne infectious diseases (e.g., cholera, salmonella, *E. coli*); zoonotic diseases (e.g., avian influenza, Creutzfeldt-Jacob disease, Monkeypox) and other emergent pathogen infections; mortality; respiratory, neurological and cardiovascular; health systems; mental health; pregnancy and birth outcomes; nutritional; skin diseases and allergies; occupational health and injuries; and other (e.g., injuries, impaired sleep, diabetes, heat stress, renal diseases).

Although the impacts of climate change have been reported in the literature, a gap remains regarding the repercussions on sociopsychological health [86]. There is growing evidence that climate change, as well as anticipation of its repercussions in the future, induces psychological distress for an increasing number of individuals. Fritze et al. have already pointed out that a deeper understanding of the long-term consequences of climate change can induce emotional distress and anxiety [87]. This form of emotional and mental state, which is associated with awareness of environmental conditions and their implications for the future, is called eco-anxiety [88]. Few specific interventions address eco-anxiety at this time (see scoping review of Baudon and Jachens 2021 [89]), as diseases or conditions associated with climate change. Climate change will also have region- and population-specific consequences, depending on relationships to the land, and can be the source of ecological grief (Cunsolo & Ellis). However, instead of taking all these problems independently, we ought to include them all within a global vision, adopting the SH concept by putting each individual in his/her environment and taking special consideration of the most vulnerable populations.

2.6. Whole-person health care

As described above, issues such as emerging and re-emerging infectious diseases, antimicrobial resistance, food security, biosafety and biosecurity are associated with changes in land use, population growth, urbanization, global travel and trade and climate change. Our perception of what health care should be needs to be reassessed and improved. We must change the traditional medical approach by integrating social and environmental factors that play a major role in modifying and maintaining health and well-being. The National Center for Complementary and Integrative Health proposes the concept of whole-person health care, which refers to four interconnected domains that must be addressed in order to improve and restore a person's health: biological, behavioral, social and environmental [90]. To better understand how each domain interacts, drastic changes should be made in research paradigm to increase intersectorality work to successfully answer actual human health challenges.

Since the inception of the Human Genome project, the speed of knowledge acquisition related to -omics domains have rapidly increased, as well as the number of large and rich biobanks in both human and environmental health domains, each of them including an amazing amount of data that remains underexploited. Sharing and pooling all these data would have the potential to raise our understanding of human health at an unprecedented level. Artificial intelligence gives us the power to deal with these large amounts of data, putting us in a better position to reach the Sustainable Development Goal 3 adopted in 2015 by the United Nations [91,92]: Ensuring healthy lives and promoting well-being at all ages.

2.7. An integrated and sustainable approach to health

The concept of SH as proposed by the CISD is based on the same principles that are guiding sustainable development, where a balance must be found between needs and resources. Besides biology and genetic factors, our model illustrates the interactions between psychosocial factors, biophysical environment and behaviors and life habits of each individual as health determinants (see Fig. 1). To reach SH, actions need to be taken at individual but also national and international levels, so we can modify, improve or limit the influence of each of these four categories on people's health. It is however a challenging goal: the availability of resources is not the same for all, due to territorial and/or economic and/or social constraints. Furthermore, the involvement of each individual into adopting or not new healthy life habits depends on many external factors including education and the accessibility to favorable environments in terms of proximity and cost.

Based on the SH model shown above, we propose adopting a new approach to design research projects, which implies to stop working independently and instead to start developing intersectoral projects aimed at studying human health by taking into account psychosocial factors, individual behaviors and environment interactions. Our approach aims at integrating existing concepts such as open science [93] and citizen science [94]. Intersectorality of research projects is essential as it also involves the inclusion of citizens through every step of the process. Science paradigms must change. They must become more inclusive and oriented toward the needs of the community, which will be possible by involving actors from different sectors outside the research community. By being involved and helping researchers to develop meaningful projects, citizen partnership could contribute in facilitating empowerment of the population and the adoption of sustainable health behaviors. Considering that resources as well as access to health care are not equally distributed and available, efforts must be put into prevention, education and promotion, with the intent of improving self-management of health by individuals, regardless of their origin or socio-economic status, while paying close attention to marginalized and vulnerable populations.

The proposed approach (see Fig. 2) is in accordance with the One

SOCIETY

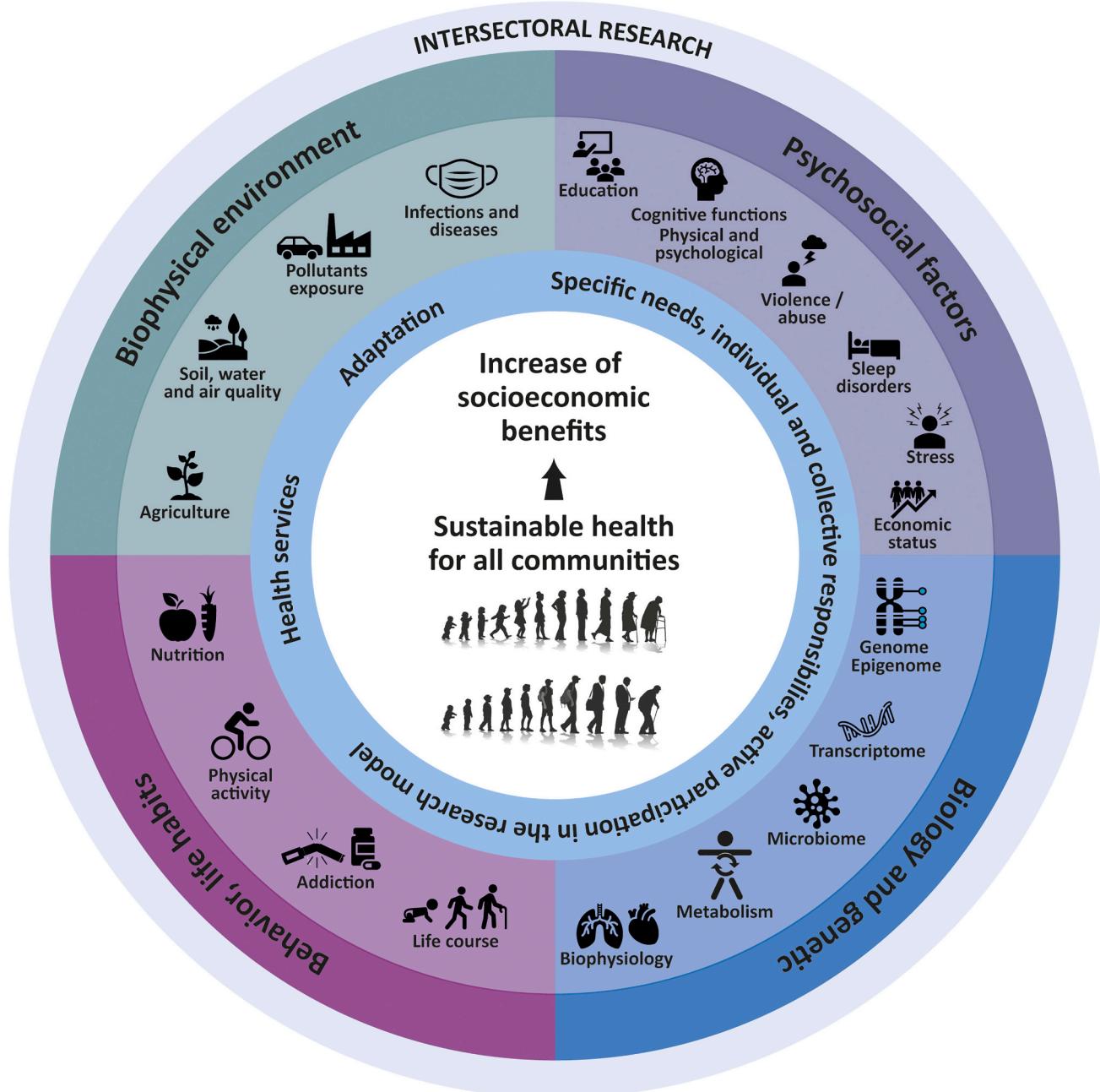


Fig. 1. Social, economic and physical environment, vulnerabilities and health cares (Sustainable Health (SH) model). SH can be achieved through intersectoral research to address the overall health of an individual and involving non-modulable factors (the individual's genome) and modulable factors (biophysical environment, psychosocial factors, behavior and lifestyle) and by the interactions between them (genetics and environment). Centre intersectoriel en santé durable de l'UQAC.

<http://cisd.uqac.ca/a-propos/definition/>

Health concept, initially defined to control and prevent zoonotic diseases. In 2004, the Wildlife Conservation Society adopted the name One World One Health to designate the holistic approach that consists of protecting public health by gaining a better understanding of relationships between animal health, human health and ecosystem health. Now simply known as the One Health approach, its principles are still relevant today, as discussed in previous sections. In 2019, the One Planet, One Health, One Future Conference was held in Germany, where 200 individuals representing governments, academia, policy and civil

society organizations from 47 countries, agreed on the 10 Berlin Principles, which urged individuals at all levels to take action in order to tackle health issues on a global scale [95]. Although it might prove difficult to address health care within a sustainable perspective, due in part to its intrinsic intersectorality, there are many reasons for a major shift in global health strategy.

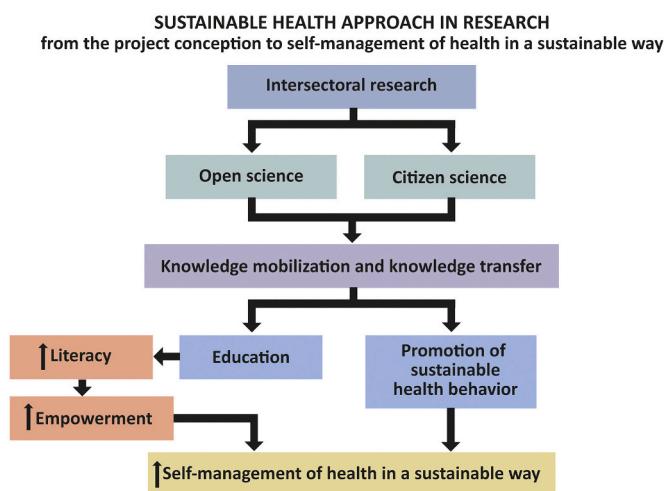


Fig. 2. Sustainable Health Approach in research diagram (modified from [2]). In the face of complex health issues, it is imperative to work in an intersectoral manner with the communities concerned (citizens, organizations, decision-makers) in order to co-construct effective solutions. These solutions will have to be evidence-based and should benefit from a network of methodologies specific to the various sectors. Citizen involvement guarantees the sharing of information and explanations, mutual listening or dialogue and leads to involvement driven by a mutual objective and a shared success in terms of the benefits inherent to the new models resulting from the research. In addition to promoting sustainable health, this approach increases education, health literacy, empowerment and translates into a self-management of health in a sustainable way.

3. Conclusion

Everybody has a role to play if we want to reach the goal of ensuring healthy lives for all. Obviously, more healthy behaviors must be adopted at the individual level. However, municipal policies are required to encourage and facilitate these changes, such as increasing accessibility to sports facilities. The same rationale can be applied for actions to be taken in addressing climate change: we must work together. As researchers, we can play an active role by developing intersectoral research projects in partnership with citizens, decision makers and industry representatives to meet the needs of the community. By doing so, confidence in science, researchers and what they promote will be improved and, at the same time, the level of compliance to the proposed evidence-based health behaviors.

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Disclosure statement

The author reports there are no competing interests to declare.

Consent for publication

Not applicable.

Ethics declaration

The work presented in this article has been carried out in an ethical way.

Data availability

Data will be made available on request.

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