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Editorial

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Welcome to Volume 1 - Issue II of the Biostatistics and Epidemiology International Journal

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Dear Colleagues and Readers:

In April 2013, I arrived on an emergency flight into a small Pacific island nation in the midst of a dengue outbreak. This island had once been the scene of some of the bloodiest battles of World War II; and was now the scene of an outbreak that was rapidly spiralling out of control. The disease was spreading rapidly, there had been fatalities, the extent of the disease on outer islands where mobile phone service and internet did not reach was unknown. In many regards, the epidemic was out of control as it overwhelmed the local medical and public health workforce. The call had gone out from both government as well as regional NGO partners for an epidemiologist to lead the local team of epidemiological technicians. At the time, I was a consultant medical epidemiologist and professor in the region, and was chosen as one of the epidemiologists available who had an interest in infectious diseases.

Within a week—thanks to the hard work, and resilient attitudes of the local public health and medical workforce—an efficient surveillance network consisting of local healthcare workers and public health practitioners had been re-established and strengthened; integrated control measures were being put into place using environmental techniques; public information in local languages on when to seek care, and when to stay home, to alleviate the overburdened hospitals and clinics, was being broadcast over radio, as well as in newspapers and leaflets; and finally, hospital-based testing had been streamlined. The unique skill-set of epidemiology had brought order to chaos.

It was with great pride that I watched the local epidemiology team now turn to understanding the nature of the epidemic, using the time-honed statistical tools that are also hallmarks of our trade. We soon found trends among patients in terms of host, agent, and environment – the analytical triad of our profession – which suggested that there was something more at work than just dengue. A small, but significant, percentage of patients did not fit the case definition of dengue agreed upon by our team, as well as world-renowned consultants from WHO and other agencies. A tropical paradise of azure blue waters and sand as white as sugar was now home to a new medical mystery; one that could only be answered using epidemiological methods.

Within a very short period of time, our suspicions had been confirmed – chikungunya was present in small, but growing, numbers, masquerading as dengue. New experts, new protocols, new trainings of local healthcare workers, new health education campaigns, all to deal with this new threat. We soon sharedour findings and made contact with key stakeholders across the region to disseminate what we had learned in terms of diagnosis and management.

All of this was made possible because of the tools of epidemiology; demonstrating once again, the ongoing vitality and ability of our discipline to respond to and address the growing threats of the Twenty-first Century.

But there is a second, equally important lesson here. And that is the story of platforms that allow researchers, no matter where they are in the world, to share their findings. Open-access journals, such as *Biostatistics and Epidemiology International Journal*, provide researchers from all areas of the world the means to share important and ground-breaking studies no matter where they work. In the case of the dengue/chikungunya outbreak in a small corner of the Pacific, we were worked on a limited budget both during the investigation, as well as in our efforts to share our important findings. Indeed, during the outbreak, our funding sources was cut in half as the local currency was devalued. Had it not been for innovative and unique means of sharing our information outside of traditional channels, our findings would have been restricted to a very small audience.

We see emerging and re-emerging threats worldwide, not just in the jungles and beaches of the Pacific. Zika remains a threat in tropical and sub-tropical areas. New strains of drug resistance are a global threat in industrialised as well as developing nations. The ongoing threat of non-communicable diseases such as type 2 diabetes, cardiovascular disease, cancer, and more threatens to engulf us no matter where we live and work. Just this week, I read an article from Victoria, Australia, on what the popular press is referring to as a 'Flesh-eating epidemic.' Buruli ulcer, caused by *Mycobacterium ulcerans*, is generally only found in Africa, but has seen a 400% increase in the last four years in Victoria, with 275 new cases last year alone. Writing in the *Medical Journal of Australia*, Dr Daniel P. O'Brien of the local health authority

states that researchers do not understand what is driving the epidemic, and that as of now it remains a mystery. A mystery that requires the tools of epidemiology if we are to understand it, how it is spread, and most importantly how to stop its spread.

Indeed, the future is bright for epidemiology, as well as for global platforms such as this, which allow us to rapidly share high-quality research done at the local level. And so, I welcome you to this latest issue of *Biostatistics and Epidemiology International Journal*, as we share world class science with real-world impact.

Warmest regards,

Dr Brian P. Mangum

Editor-in-Chief

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Monography

Biostatistics and Epidemiology International Journal

Social epidemiology and determinants of health in Fiji: social, cultural, and environmental factors influencing public health status, climate change and rates of Leptospirosis

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Abstract

Social determinants of health play a major role in the development of sustainable healthcare systems in much of the Pacific. This includes Fiji, which is the largest of the Pacific island nations, and is in many ways a leader if health in the region. Despite this, Fiji, along with the entire Pacific, continues to labour under a heavy burden of both non-communicable, as well as communicable diseases, including emerging and re-emerging infectious diseases, such as leptospirosis, all of which is mediated by economic conditions and the growing threat of climate change. This monograph explores the social epidemiology of health determinants of health in Fiji from the standpoint of social, cultural, and environmental factors; before looking at the impact of such on public health systems and population health status, climate change and disease rates, and finally, the impact of such on the rising rates of leptospirosis regionally.

Keywords: social determinants, social epidemiology, Fiji, leptospirosis, public health, wealth distribution, food security, prejudice, climate, change, environmental health, infectious diseases

Social epidemiology and determinants of health in Fiji, the South Pacific

Fiji is an island nation located in the South Pacific east of Hawaii and north of Australia and New Zealand. With a population of just over 800,000,[1] Fiji is the largest population hub of the Pacific islands, and is the economic and educational centre of the South Pacific. With approximately 160 islands, the demographics, health, and public health status of Fiji varies widely from the urban centres of Suva, Sigatouka, Nadi, Lautoka, and Labasa; to the small, sparsely inhabited islands of the outer groups.[1] The bulk of the economy of Fiji is based on tourism, with the majority of resorts found on the larger islands, such as Viti Levu, which is home to the capital and largest city of Suva, as well as three of the other large population centres.[1]

For a Pacific island nation, the healthcare and public health infrastructure of Fiji is highly developed; however, such development is below that of industrialized nations such as the United States. Still, Fiji is home to two medical schools, including the College of Medicine, Nursing, and Health Sciences of Fiji National University (FNU), and the University of the South Pacific; two nursing schools, one located within FNU, and an additional private nursing school; and a large number of allied health programs found within FNU, including dentistry, radiography, laboratory science, pharmacy, and public health at the undergraduate and graduate levels. The Ministry of Health (MOH) of Fiji is responsible for both medical and public health services. Fiji is serviced by a single referral and teaching hospital in the form of Colonial War Memorial Hospital in Suva, and additional divisional hospitals in the major population centres, sub-divisional hospitals serving smaller communities, and nursing and medical posts in remote areas. Each division of the healthcare system is also supported by an associated division of the public health system. Despite a robust organizational structure, in practice there are significant areas for improvement in both the medical and public health spheres, including a lack of specially trained human resources in areas such as epidemiology and medical subspecialties, as well as the need for additional physical and economic resources for preventative services.

The purpose of this paper is to examine the generalized social determinants of health for Fiji as mediated by regional issues such as climate change and rapidly growing rates of non-communicable diseases (NCDs) such as type 2 diabetes, obesity, and cardiovascular disease through the lenses of physical and social factors present in the islands; and then to discuss how these factors have contributed to an ongoing burden of infectious diseases in the region, specifically leptospirosis, including a discussion of the impact of leptospirosis as mediated by cultural and social factors.

The role of social and environmental determinants of health in Fiji

As previously mentioned, the role of culture is highly important in Fiji for both indigenous Fijians as well as Indo-Fijians. So important is

the role of culture, that cultural holidays such as Diwali are celebrated as bank holidays, and are official days off from work and school. Given the role of the social environment in the lives of Fijians, it is not surprising then that the social environment also impacts the determinants of health in the country. The physical environment also plays a major role, given that Fiji consists of a large number of islands, both urban and rural centres, and both developed and developing areas in terms of economics, education, and so forth. This section will look at the role of social and environmental determinants of health in Fiji, including wealth distribution, education, the role of culture in the lives and opportunities of women and children, the role of prejudice in health, access to public health, access to housing and sanitation, as well as food and shelter security.

Wealth distribution in Fiji

Fiji is an economically developing country, with the bulk of the population living below the poverty line, or making less than $8,000 FJD (Fijian dollars) per year.[2] Economic opportunities are scarce, with the largest sector of the economy, or nearly 60% being represented by the tourism sector (2006). The bulk of tourists come from Australia, New Zealand, North America, and increasingly China.[2]

Following the 2014 elections, Fiji has returned to a democratically elected government after a history of four coups dating to the 1970s turnover of power from Great Britain to local government.[1] In the run up to this election, and since then, there has been rapid economic development underpinned by investments from China as well as Australia, and to a lesser extent the United States.[1] The result is a widening income gap between a small but rapidly increasing upper class who control Western-style economic development projects; a small, but growing middle class of merchants and professionals, such as physicians and attorneys; and the large lower class who work in a variety of service industry occupations related to tourism, sales, domestic work, and so forth. Socioeconomic development opportunities, such as electricity and education for all areas of the country, have been promised by the newly elected government, and in theory will provide the opportunity for the lower and middle classes to grow in terms of wealth and access to services; however, things remain in the early stages post-election, and such development will require several years, if not a decade of more, to reach fruition.

Educational attainment and access in Fiji

Fiji provides education through grade school in most communities, including rural and isolated communities, and through high school in most urban centres. Beginning in 2013, school fees are paid by government, thus removing the economic strain felt by many families in having to pay school fees for multiple children, which in the past caused many children to miss entire years of school. Parents and caregivers must still pay for uniforms and school supplies, including book fees, which remains onerous for many families.

Tertiary education is available through Fiji National University, which provides business, law, engineering, health science, dentistry, and medical education among other programs. University of Fiji provides liberal arts schooling environment, including business, law, the arts, and recently a private medical school. University of the South Pacific, which is the largest tertiary provider in Fiji and the South Pacific, provides a broad-based program of study at the undergraduate and graduate level, including arts, sciences, and law; noticeably, University of the South Pacific does not provide education in the health sciences or medicine. Most students do not attend university as private pay students, such as would be found in the United States, but compete for limited scholarships. A recent student loan program has been introduced, and the number of private pay students is increasing. From a development standpoint, it has yet to be seen whether increased access to education will increase social and economic opportunities, or whether it will result in a student loan issue similar to those found in the United States in an atmosphere where there are limited opportunities for graduates. In such an environment, many graduates work to go overseas to Australia or New Zealand on graduation.

The impact of culture on women and children in Fiji

A recent report found that two-thirds of all women and children living in the Pacific, including Fiji, have been abused (Fiji Ministry of Health [MOH], 2014a; WHO, 2011).[3,4] The current culture of Fiji is changing to allow for greater opportunities for women, particularly those coming from urban centres, but in rural areas women remain subservient in terms of economic and social opportunities. In indigenous Fijian villages the village chief and counsel are all males; and hence all decisions at the local level are governed by the patriarchy, with women not being allowed to enter the village hall or speak.[5] Women are largely responsible for the preparation of food, gathering of fire wood, raising of children, and the maintenance of the home.[5,6] Indo-Fijian culture is similar, with women being primarily responsible for the maintenance of the home and the care of the children. A common statement among Indo-Fijian fathers is that daughters are a *blessed burden*.[6]

In urban areas, abuse continues, but there are opportunities for women to be involved in the social and economic hierarchy of life: attending university, holding important positions in government and industry, such as serving as the dean of a college or the head of the South Pacific Stock Exchange, serving as members of the newly reinstated parliament, and altering the social dynamic slowly so that women are attaining success and respect.[7] However, just as economic development post-2104 elections will take time to demonstrate improvement, so will the associated gains of women in terms of economic and social opportunities to excel and lead.

The role of prejudice in health

Given the socioeconomic history of Fiji under British rule, including the importation of Indians from India for slave and indentured labour in sugar cane plantations, who subsequently stayed on and have become a significant political and economic force in the country, even leading one of the four coups, it is not surprising that there is a level of prejudice which influences health and access to healthcare services. Indo-Fijians have long been members of Fijian society. The population is the second largest in Fiji,[2] having grown significantly since their beginnings as slave and indentured labourers. Indo-Fijians have risen to high levels of government, have been involved in politics, including leading one of the four coups, and have risen to high levels in commerce and education. Despite this, there is significant prejudice against Indo-Fijians by indigenous Fijians, including limitations on citizenship, property and business ownership, and inheritance.[1] All such restrictions have been removed legally from the system, and in the post-2014 democratic systems Indo-Fijians serve as ministers and parliamentarians; yet, a system of prejudice does remain under the surface.

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Other prejudices exist against those with certain medical conditions, including HIV/AIDS patients, including limitations on access to care, outright fear of the disease and its impact on the population, cultural taboos, and a widespread association of HIV/AIDS with the homosexual population of Fiji.[2]

Quality of housing and sanitation in Fiji

The quality of housing varies widely. Those living in the upper middle class and upper class live in quality homes with access to Western-style sanitation, electricity, clean water, gardens, and a variety of domestic servants who are available for inexpensive rates. At the other end of the spectrum are those living below the poverty line in urban centres in what are known as squatter settlements. Squatter settlements are located on Crown land which is unoccupied except for villages composed of scrap lumber and corrugated iron which seem to crop up overnight in major centres such as Suva. Electricity and clean water are generally not available through government services; rather, relying on tapped power and well lines which amount to stolen water and electricity from municipal sources.[8] In rural areas villages generally have access to water from traditional sources, such as wells and rivers, and may or may not have electricity access.[2] For those which have electricity, it is on a pay-as-you-go system, similar to prepaid mobile phones. In many ways, the quality of housing in rural areas is higher, as is the quality of sanitation.

Food security in Fiji

A recent report suggests that a large number of women and children in Fiji are malnourished, while at the other end of the spectrum is the issue with obesity.[9,10] In rural areas infants are frequently identified as suffering from failure to thrive; although, the relative lack of access to healthcare and screening in rural areas limits treatment options.[10] During a recent medical civil affairs survey of a rural village, large numbers of anaemic women, asthma, untreated osteoporosis and osteoarthritis, were all identified within ten kilometres of a rural hospital; however, villagers stated that even that was considered too far to travel, despite access to bus service, and thus individuals were simply expected to bear their disabilities with good humour.

Food security need not be an issue in rural areas where access to land for planning of crops such as dalo, kasava, fruits, and vegetables is readily obtainable, if the land is worked. However, in urban areas families living below the poverty line must pay higher prices, particularly in the capital of Suva—which is home to embassies, the United Nations, the World Health Organization, the Secretariat of the Pacific Community, the European Union, and so forth—prices are very high owing to competition for quality goods by the growing upper classes and expatriate population. As such, coconuts which go for less than $1 FJD in rural areas, will cost $2-3 FJD. A similar situation is seen in areas such as Nadi and Lautoka, the tourist hubs of the country, where tourist prices make things overly expensive for the local population, which has not seen a concomitant raise in wages. Thus, to an extent urbanization and economic growth is providing opportunities for only a small percentage of the population, while the lower socioeconomic classes suffer under inflation.

Public health status of Fiji

Public health services are handled by the Ministry of Health, with the advantage/disadvantage of being co-located alongside the medical system. This is an advantage in that the financial and human resources decisions that impact the allocation of resources for both public health and medical services are made by the same key stakeholders; while at the same time, in a country and region where non-communicable diseases (NCD) threaten to overwhelm response capabilities, public health is often seen as secondary in the face of meeting the immediate medical needs of patients who require care for type 2 diabetes, cancer, and so forth. While it would seem apparent that greater public health interventions would lead to lower rates of NCDs, the Ministry of Health is in the difficult situation of meeting the acute needs of a population while also planning for long-term care and prevention in a resource limited environment.

Dual role of medical management and outbreaks

There is no shortage of healthcare providers, with two in-country medical schools, as well as allied health disciplines; however, what is limited is access to advanced training and care.[10] Local primary care clinics are run as part of the public health system, with health promotion officers and environmental health officers part of this system; however, their budgets and ability to effect real change are limited. For example, a 2014 outbreak of typhoid fever in the small village of Wailoku, located just outside of the capital of Suva, which resulted in several fatalities, went unnoticed until accidently discovered during an in-hospital surveillance sweep for leptospirosis. The results were swift and definitive in terms of the response by public health authorities; however, had it not been for a non-associated surveillance program identifying cases on different wards from Wailoku, then the outbreak would have continued unchecked and more deaths would have occurred.

Physical and environmental factors influencing public health in Fiji

A growing association between the physical environment and health is recognized in Fiji and throughout the Pacific. This includes an understanding of the association between urbanization, economic growth in Asia, and the resultant issues associated with climate change and the emergence and re-emergence of both NCDs and infectious diseases as ongoing threats to the threat security of the region. This section will look at issues related to climate, drought and climate change, and the role of environmental changes in the incidence of NCDs.

Climate, climate change, and disease rate

Fiji has a year-round tropical climate subject to changes in weather patterns, such as a rainy and a dry season, as mediated by droughts as well as flooding; often times, Fiji will experience disparate weather patterns, including droughts in the Western regions which have a climate similar to Southern California, to monsoon-style weather in the Easter regions similar to that found in Darwin in central north Australia.[10] These seasonal variations are expected, and in terms of their impact on health can be managed through experience, including an increase in febrile zoonotic illnesses, such as leptospirosis, dengue, and typhoid, during times of heavy rains and flooding, to increased cases of asthma, heat stroke, and so forth associated with the dryer times of the year.

However, growing concerns over the impact of climate change as well as weather patterns associated with El Niño and La Niña, suggest

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that non-cyclical climate patterns may result in disease rates which are more difficult to manage from either a direct medical or public health preventative standpoint given the limited resources available in Fiji.[11] NCDs and climate change are interlinked through an increase in pollution—which is a significant problem in the urbanized areas of Fiji where unregulated economic growth has resulted in pollution from busses, taxis, and other modes of transportation and economic development—resulting in higher rates of cardiovascular disease, lung disease, and even certain forms of cancer.[12,13]

It should also be noted that as climate change increased the number of atmospheric events associated with floods and tsunamis that the incidence of vector-borne illnesses will also increase owing to increased breeding opportunities for mosquitoes and other vectors. At the other end of the spectrum, Fiji and many other Pacific island nations are now experiencing droughts, which have caused economic hardship through the loss of agricultural animals, such as cows, and the loss of crops.[10] The result has been an increase in economic pressure on farmers and ranchers, as well as those who must now purchase agricultural products at an increased rate.

International relationship between climate change and health

In terms of the relationship between these factors and their influence on health at the local and international level, it is important to note that while local factors, including increased urbanization and economic development, have impacted rates of both NCDs and infectious diseases, that the development of such is largely rooted in multinational issues related to rapid and largely unregulated international development in both the Americas as well as Asia. In regard to the Pacific, such is primarily rooted in the development of the Chinese economy within China, within the Pacific Rim countries influenced by Chinese economic and development policy, and locally within Fiji.

Chinese development has been associated with climate change, including the increased use of coal and other fossil fuels in the manufacturing of goods for export and sale overseas.[14,15] The increased use of fossil fuels is associated with increased climate change, which in turn is associated with an increase in both infectious and chronic diseases.[12,16] Locally, the impact is seen in two ways: an increase in atmospheric events off-cycle from normal weather patterns as events such as El Niño and La Niña; and an increased emphasis of China on using the Pacific as a de facto spot to wage economic colonialism and an economic version of the Cold War against the United States, Australia, New Zealand, Europe, which to a great extent of long neglected their political and economic support of regional nations such as Fiji. This is coupled with economic investments in Fiji and the Pacific in the form of hospitals, roads, infrastructure, as well as economic projects, such as hotels, apartment buildings, construction firms, and large-scale agricultural production for the region.[17,18] The result being that not only is there a local increase in NCDs and infectious diseases from climate change associated with China as a superpower of world commerce, but also locally through urbanization and the impact of climate and environment—such as in increase in asthma, chronic obstructive pulmonary disease (COPD) and other issues associated with air quality, and increased encroachment of development into areas previously remaining in a natural habitat, but with which has come increased exposure to zoonotic vectors of disease, such as mosquitoes and fruit bats.[19]

The role of Leptospirosis on public health in Fiji

One significant area of concern in relation to the local and international impacts of the social, economic, political, and climate change environment on the health security of Fiji is the emergence and re-emergency of infectious illnesses. This includes leptospirosis. Leptospirosis is one of the acute febrile illnesses common in tropical countries.[20] As a zoonotic, Leptospirosis is spread through the infected urine of cows, dogs, cats, rats, and possibly other animals.[21] Leptospirosis is generally spread in Fiji following periods of intense rainfall and flooding through agricultural pursuits, or coming in contact with water that contains urine from infected animals. Farmers and those living in rural areas, where leptospirosis rates are highest, rarely wear shoes or rubber irrigation boots, and thus can become infected through cuts or sores in their feet or legs.[22]

Public health campaigns to address leptospirosis should focus on health education at the local level, as barrier protection, such as wearing protective footwear is effective against the acquisition of leptospirosis; as well as efforts to develop a vaccine to address not only human cases of leptospirosis, but also bovine cases, as there is a significant economic cost associated with cows who are infected, given that mother cows with leptospirosis have high levels of spontaneous abortions. Other efforts should look at policy-level interventions to target climate change and disaster preparedness efforts, given that climate-associated events traditionally result in an increase of cases each year in Fiji following not only the rainy season, but also floods associated with increased severe rainfall, tsunamis, and cyclones.

Social determinants of Leptospirosis

The social determinants of leptospirosis are associated with two areas: first, a lack of education and a lack of health literacy on the part of populations who are at risk for leptospirosis; and two, a lack of economic ability to purchase and utilize barrier protection in the form of rubber irrigation boots by farmers and those working in areas where exposure to infected cow and other urine is present.

There is a lack of education on the risks of leptospirosis in rural areas where the rates of the disease are highest in Fiji, such as the Nausori corridor which has high rates associated with dairy farming. Furthermore, before such education can occur, there is a need to develop the health literacy of the population in at-risk areas, so as to allow them to understand the risks and prevention of leptospirosis. Such could take the form of a public health education campaign using text messages, which are widely used even in rural areas; local churches and community organization, and local shops, since every small community has these; and finally, using cultural and language specific educational materials that are written at an appropriate level for understanding. However, such cannot succeed unless it is accompanied by an intervention to provide access to the most common preventative aid: rubber irrigation boots, which are not widely used, available in rural areas, and expensive.

Providing education and access to irrigation boots would overcome the social barriers to the prevention of leptospirosis in rural Fiji. Access would need to be provided through partner grant agencies, such as the European Union or the Australian Agency for International Development either as an outright gift or through subsidized purchase. Before proceeding to the provision of boots, and under a model similar to that of the Health Belief Model (HBM), it is important that

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the health education campaign provide significant awareness and self-efficacy that the boots will actually be utilized.

The impact of global public health on Leptospirosis in Fiji

Global public health has a significant role to play in leptospirosis surveillance and eradication efforts in Fiji and the Pacific. This includes: efforts and partnerships to increase surveillance; identification of areas where eradication of dogs and rats as carriers is needed; identification of areas where treatment of cows would be an effective economic intervention; identification of areas where human education and treatment would be effective; identification of areas where data on serotypes for vaccine development can be gathered; and finally, the development of a vaccine in concert with multinational organizations.

Currently, there is an ongoing regional project between Fiji National University, University of Queensland, the Fiji Ministry of Health, the Fiji Centres for Disease Control, and the Institut Pasteur to address these issues. It should be noted that this is a multipronged effort designed to address immediate economic and healthcare-related needs, through surveillance to identify human populations that are in need of treatment, and may have been misdiagnosed as having dengue, as well as bovine treatment to lessen the cost associated with spontaneous abortions of cows. The surveillance data is also being used to identify areas for health education efforts, eradication of dogs and rats through trapping and euthanizing, as well as testing which serotypes are most prevalent and hence would most likely respond to a vaccine in the next decade. Because this is a multinational effort, it brings to bear the different talents and resources of agencies both inside and outside of Fiji, and takes into account the social and cultural determinants of the disease at the local level.

Conclusion

Health and development in the Pacific, and in particular, Fiji, are inexorably linked. Without development, given the rapidly changing economic landscape, there cannot be the socioeconomic and political infrastructure needed to support healthy lifestyle choices among a population which is still largely economically disenfranchised, with lower levels of educational development and political enfranchisement, than other middle- and high-income nations. This leads to situations of rapidly growing rates of NCDs, as well as emerging and re-emerging communicable diseases such as Leptospirosis, which themselves are influenced by climate change as a mediator of zoonosis, and whose prevalence rates are largely impacted by social determinants of health, such as the ability to make healthy lifestyle choices, given limiting financial circumstances. As such, there is not just a need to focus on meeting the immediate medical needs of a population plagued by this dual burden of disease; but also to look to the future in terms of an integrated population-based approach that takes into account the need for sustainable development focused on engaging Fijians at all economic levels, and not simply on economic development that benefits a relatively small percentage of the population, as well as outside investors and nation state actors. Such presents an immediate challenge to a system of development that silos different economic sectors, such as education, health, disaster risk management, climate change, and so forth. Without an integrated approach that looks at development as a cross-cutting issue focused on immediate and long-term needs, there can be no change in the rates of disease which currently plague Fiji at both endemic and epidemic levels.

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Research

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Physical activity and overweight/obesity among academic stressed adolescents

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Abstract

Objectives: This study investigated the relationship between physical activity level and overweight/obesity among academically-stressed Chinese middle school students.

Methods: One thousand eight hundred and ten (1,810) high school students were recruited from the 10th-12th grades (805 girls and 1005 boys) from a high-school located in Jiangxi Province of China. Students' risk behaviors were assessed using the Youth Risk Behavior Survey. The Kruskal-Wallis H test and ordinal regression model analysis were employed to identify the relationship between physical activity, academic stress and overweight/obesity.

Results: The Kruskal-Wallis H test and ordinal regression model analysis indicated a statistically significant correlation between academic stress and overweight/obesity among Chinese adolescents, and perhaps physical inactivity is a mediator of this association.

Conclusion: Low physical activity and increasing obesity trajectories among Chinese high school adolescents have become a concern in China; thus, it is imperative to promote participation in physical activity and to build a long-standing mechanism to improve the overall health condition of youths.

Keywords: physical inactivity, youth behavior, academic stress, overweight/obesity

Introduction

It has been recommended that school-aged children and adolescents should accumulate at least 60 minutes of moderate to vigorous intensity level of physical activity (MVPA) per day for health benefits.[1] Traditionally, the foremost objective of studies reporting on levels and patterns of physical activity performed by adolescents has been to determine the amount of coherence between recommended and actual MVPA levels. However, data suggest that the majority of youth do not meet these guidelines. Specifically, more than 80% of adolescents spend less than 60 min of MVPA per day.[2]

In recent years, there has been a decline in the physical activity levels of Chinese adolescents.[3] Researchers have claimed that the most basic and direct reason for a decline in fitness is insufficient physical activity.[4,5] Participation in physical activity is not only associated with the external environment factors but is also related to attitude towards an activity or sport.[6,7]

With the increasingly fierce competition, the employment pressure is becoming more and more serious, brings more academic stress and pressure of getting into a key university to high school students. Previous studies have suggested that a proper amount of physical activity time can effectively reduce stress to a certain extent, eliminate fatigue, and maintain optimal mood for learning. In addition, proper levels of physical activity can improve concentration, attention, and on-task behavior. Although the benefits of physical activity are obvious, why are Chinese high school students' physical fitness levels declining?

High school students are the hope and the future of our society, but their physical health condition is becoming worse, which has already caused or will cause certain negative impacts on their current and future well-being.[8] The primary objective of this study was to determine the prevalence and investigate factors associated with daily health behaviors and physical activity in high school students in China. The relationships between overweight/obesity or academic stress and physical activity levels were investigated. It was hypothesized that the results of this study would show further evidence of an emerging threats of obesity, academic stress, and inadequate physical activity in high school students in China while also showing novel correlations between these outcomes and diverse causes of fitness decline in this context.

Methods

Setting and data source

A group of 10th grade and 11th grade students enrolled in a high school in Jiangxi Province was recruited in this study. This was a cross-

sectional study, and a questionnaire was used to assess their health risk behaviors. We did not survey 12th graders because their study time for the entrance examination was too valuable to disrupt. Students in this study came from urban and rural areas. A total of 1900 questionnaires were initially administrated, removing the five students who had left the school or were absent; the rest of the students participated in the questionnaire. A total of 1810 questionnaires were completed and returned, for a response rate of 95.26%.

Questionnaire design

The Youth Risk Behavioral Surveillance System Survey (YRBSS) was used to assess participants' risk behaviors. This survey is a biennial state-based epidemiologic surveillance system coordinated by the U.S. Centers for Disease Control and Prevention (CDC).[9] Questions were modified to reflect Chinese culture. The survey consisted of 84 questions in eight categories: (1) Demographic characteristics; (2) Harm behavior; (3) Smoking behavior; (4) Drinking behavior; (5) Eating behavior and body weight; (6) Physical activity; (7) Sexual behavior and other health-related behaviors; (8) Academic stress. The survey was administered to each class as a unit. Students were asked to answer the questions anonymously and independently, and the questionnaires were collected immediately following completion.

Study variables

Physical activity, time spent studying, and academic performance students were asked three questions to assess their level of physical activity, time spent studying, and academic performance (Table 1). For physical activity, students could respond "0, 1, 2, 3, 4, 5, 6, or 7 days". These were recoded as "sedentary time," "light intensity," "moderate intensity," and "vigorous intensity" in order to analyze the influence of physical activity.[10–12] For time spent studying, students could respond "less than 7 hours", 7 hours, 8 hours, 9 hours, or 10 or more hours" per day. These were recoded as "short time" for 7 hours or less and "long time" for 8 or more hours per day (Table 1). For academic performance, students were asked what their grades were over the past 12 months. Students could respond "mostly A's, B's, C's, D's, E's" or "Other grades." These were recoded as "good grades" for mostly A's or B's, "Average grades" for mostly C's or D's, "Poor grades" for mostly E's, and "None of these grades/not sure" for responses of "other grades" (Table 1).

Academic stress

Two questions were designed to assess students' academic stress level and source of stress, respectively: (1) "What level of stress do you feel as a result of your studies?" (2) "What is the primary reason for your stress?" For question 1, students could answer "very stressed", "above average stress", "average stress", "below average stress" or "no stress." For question 2, students could select more than one answer from the answer choices: "exams," "getting into a key university," "parents," "teachers," "yourself," and "other." The number distribution of the answers to Question 2 has been shown in Figure 1.

Table 1 Description of specific health risk behaviors and categorizations.

Health behavior	YRBSS Question	Recoding of Responses
Physically active for 60 min per day	During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?	sedentary time: 0 days light intensity: 1-2 days moderate intensity: 3-4 days vigorous intensity: 5-7 days
Hours of study per day	How many hours per day do you study on a school day?	Short time: ≤ 7 hours, Long time: ≥ 8 hours
Grades over past 12 months	During the past 12 months, how would you describe your grades in school?	Good grades: Mostly A's, Mostly B's Average grades: Mostly C's, Mostly D's Poor grades: Mostly E's Other grades: None of these grades, Not sure

Body Mass Index

Body Mass Index (BMI) is a body composition measure that is derived from weight and height (kg/m^2) of an individual. The BMI attempts to quantify the amount of tissue mass (muscle, fat, and bone) and is then categorize the individual into different weight zones: "underweight," "normal weight," "overweight," or "obese." In this study, high school students' weight and height were self-reported. BMI was then calculated and categorized into a weight zone using Chinese youth BMI criteria (Table 2).

Quality control

Both the sample selection and the questionnaire survey for this study were conducted in strict accordance with the design plan. The questionnaire was designed for the specific needs of this study based on the United States CDC YRBSS questionnaire by professors from the University of Nevada, Reno in the U.S., and Nanchang University in China. Qualified and trained graduate students from the two institutions implemented and conducted the survey. In addition, teachers at the high school were trained to use the same language when explaining the directions to students. The survey was completed independently by students based on their own understanding of the questions in order to avoid introducing bias. Investigators and data collectors participated in a debriefing meeting to examine the data, and logical verification of the responses was conducted to help ensure data accuracy.

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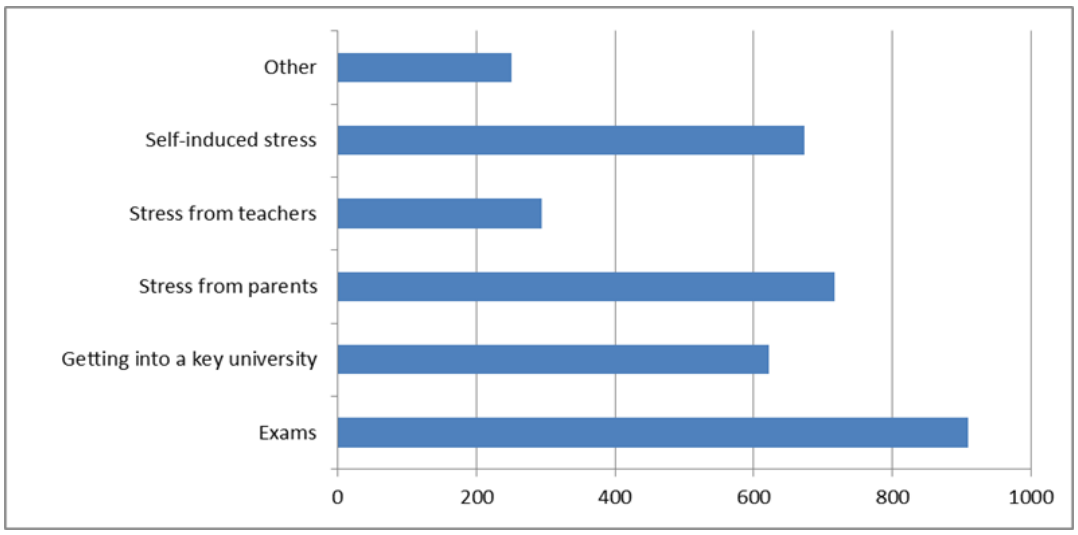

Figure 1 The number distribution of the answers to the primary reason for academic stress

Table 2 Chinese cut off points for body mass index for overweight and obesity by sex between 7 and 18 years.

Age	Male		Female	
	Overweight	Obese	Overweight	Obese
7~	17.4	19.2	17.2	18.9
8~	18.1	20.3	18.1	19.9
9~	18.9	21.4	19.0	21.0
10~	19.6	22.5	20.0	22.1
11~	20.3	23.6	21.1	23.3
12~	21.0	24.7	21.9	24.5
13~	21.9	25.7	22.6	25.6
14~	22.6	26.4	23.0	26.3
15~	23.1	26.9	23.4	26.9
16~	23.5	27.4	23.7	27.4
17~	23.8	27.8	23.8	27.7
18	24.0	28.0	24.0	28.0

Statistical analyses

A database of the survey responses was created using EpiData 3.1 software. SPSS Version 20.0 (IBM Corp., Armonk, NY, USA) was then employed for descriptive and statistical analyses. A descriptive analysis was conducted to describe the sample characteristics. Wilcoxon rank sum test and Kruskal-Wallis *H* test were then used for the single factor analysis. Ordinal regression was conducted for the multi-factor analysis. The significance level was set at 0.05 for all statistical analyses.

Results

Demographic data

Of the 1810 total senior high school students in the study, 1005 (55.5%) were male and 805 (44.5%) were female. The students were rarely under 14 years old (n=5, 0.3%). Ninety-one (5.0%) students were 15 years old, 553 (30.6%) were 16 years old, 867 (47.9%) were 17 years old, and 294 (16.2%) were 18 years or older. Most of the students (81.0%) come from the countryside, while 19.0% of the students were from the town. Nearly half of the students were living with both parents (45.5%, n=824) or in the school dormitory (45.5%, n=824); students rarely lived with other family/relatives (n=135, 7.5%), with other students (n=12,0.7%), or in a house by themselves (n=15,0.8%). There were 874 (48.3%) students whose father, mother or both parents leave for work. Forty-three-point-four percent of students' education track was science, and 56.6% of students' education track was arts (Table 3).

Related demographic or behavior characteristics of different levels of youth physical activity

The Kruskal-Wallis *H* test was employed to examine the differences on students' demographic or behavior characteristics, and physical activity level. The results indicated that students' height, weight, gender, BMI, weight classification, learning time, and academic stress were significantly correlated with physical activity level (Table 4).

Estimation of ordinal regression model on physical activity influential factors

The model structure is depicted in three sections: Physical activity was classified into sedentary time, light intensity, moderate intensity and vigorous intensity as the dependent variable, the gender, BMI classification, learning time, and academic stress were as the independent variables, using Logit as link function and assigning them to variables (Table 5).

The likelihood ratio test of the model showed that ordinal regression model was significant, and the test of the parallel line means the fitting model has statistical significance. The model showed that there was a statistically significant influence of gender, BMI classification, time spent learning, and level of academic stress on physical activity level. Girls spent less time participating in physical activity than boys did. Students who spend more time on learning tended to be less physically

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active. A negative relationship was found between physical activity and academic stress; in other words, students who had a lower level of academic stress tended to have a higher physical activity level. Finally, students who were overweight or obese were less physically active than students whose weight was normal according to their BMI.

Table 3 Demographic characteristics of the sample, number (n) and percentages (%).

Characteristic	Female (n,%)	Male (n,%)	All (n,%)
Age			
14 years old or young	4(0.5)	1(0.1)	5(0.3)
15 years old	44(5.5)	47(4.7)	91(5.0)
16 years old	250(31.1)	303(30.1)	553(30.6)
17 years old	373(46.3)	494(49.2)	867(47.9)
18 years old or older	134(16.6)	160(15.9)	294(16.2)
Place of residence			
Rural	651(80.9)	816(81.2)	1467(81.0)
Urban	154(19.1)	189(18.8)	343(19.0)
Living arrangement			
With parents	336(41.7)	488(48.6)	824(45.5)
With other family/relatives	52(6.5)	83(8.3)	135(7.5)
In school (dormitory)	409(50.8)	415(41.3)	824(45.5)
In a house with other students	4(0.5)	8(0.8)	12(0.7)
In a house by yourself	4(0.5)	11(1.1)	15(0.8)
Parents leave for work			
Yes	388(48.2)	486(48.4)	874(48.3)
No	417(51.8)	519(51.6)	936(51.7)
Science or Humanities Division			
Sciences	235(29.2)	550(54.7)	785(43.4)
Arts	570(70.8)	455(45.3)	1025(56.6)
total	805	1005	1810

Table 4 Youth physical activity status according to selected independent variables ($\overline{X}$ ± S or %).

	Physical Activity Level					
Demographic or Behavior Characteristics	**Sedentary time**	**Light intensity**	**Moderate intensity**	**Vigorous intensity**	χ^2 **or** ***H***	***p*-value**
Height	164.8±21.4	165.8±7.3	166.7±7.9	170.0±31.0	50.795	0.000
Weight	54.0±9.6	55.1±9.6	55.4±10.2	54.0±8.4	9.056	0.029
Age (years)					17.683	0.126
≤14	46.2	7.6	30.8	15.4		
15	69.9	17.2	5.4	7.5		
16	63.5	20.6	8.5	7.4		
17	60.7	19.8	9.1	10.4		
≥18	65.6	18.2	7.0	9.2		
Gender					63.882	0.000
Female	71.6	18.1	5.2	5.1		
Male	55.8	20.9	10.8	12.5		
Place of residence					1.606	0.658
Rural	63.5	19.2	8.3	9.0		

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Table Continued

	Physical Activity Level					
Demographic or Behavior Characteristics	**Sedentary time**	**Light intensity**	**Moderate intensity**	**Vigorous intensity**	χ^2 **or** ***H***	***p*-value**
Urban	59.8	21.7	8.7	9.8		
Living arrangement					6.662	0.879
With parents	61.3	20.4	8.7	9.6		
With other family/relatives	63.5	19.0	8.0	9.5		
In school (dormitory)	64.0	19.3	8.1	8.6		
In a house with other students	53.8	15.4	15.4	15.4		
in a house by yourself	80.0	6.7	0.0	13.3		
Parents leave for work					1.260	0.739
Yes	64.0	18.9	8.0	9.1		
No	61.6	20.4	8.7	9.3		
Science-humanities division					3.509	0.320
Sciences	62.4	18.5	9.6	9.5		
Arts	63.1	20.5	7.4	9.0		
Hours of learning per day					11.654	0.009
Short time	68.0	16.0	7.2	8.8		
Long time	60.1	21.5	9.0	9.4		
Grades over past 12 months					8.179	0.516
Good grades	66.6	17.2	7.4	8.8		
Average grades	61.1	20.7	9.6	8.6		
Poor grades	62.2	20.5	7.2	10.1		
Other grades	63.7	18.1	6.9	11.3		
Academic stress					95.847	0.000
Very stressed	70.0	17.9	6.5	5.6		
Above average stress	63.5	19.2	8.4	8.9		
Average stress	61.1	21.0	9.7	8.2		
Below average stress	51.4	23.6	8.3	16.7		
No stress	31.1	21.6	10.8	36.5		
BMI Classification					41.994	0.000
Normal weight	64.2	18.9	7.6	9.3		
Overweight	43.1	28.7	16.0	12.2		
Obese	71.5	16.8	6.7	5.0		

Table 5 Variable assignment of ordinal regression.

Characteristics	Variable name	Factor assignment	Number	Ratio(%)
Physically activity	Y	sedentary time=1	1135	62.7
		light intensity=2	356	19.7
		moderate intensity=3	152	8.4
		vigorous intensity=4	167	9.2
Gender	X_1	female=1	805	44.5
		male=2	1005	55.5

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Table Continued

Characteristics	Variable name	Factor assignment	Number	Ratio(%)
Hours of learning per day	X_2	short time=1	602	33.2
		long time=2	1208	66.8
Academic stress	X_3	very stressed=1	513	28.3
		above average stress=2	595	32.9
		average stress=3	555	30.7
		below average stress=4	73	4.0
		no stress=5	74	4.1
BMI	X_4	about the right weight=1	1446	79.9
		overweight=2	183	10.1
		obesity=3	181	10.0

Discussion

This study was designed to investigate the relationship between overweight/obesity or academic stress and physical activity levels. The results suggested that the gender was an independent factor of high school students' physical activity. Specifically, the male participants in this study demonstrated higher physical activity level than their female counterparts; the same finding has been echoed by studies that were conducted in both China and abroad[13,14] and indicates preferential differences for physical activity between genders. Male students prefer to engage in intense extracurricular physical exercise to express their youth and vitality. As adolescent girls tend to become more conscious of and pursue cosmetic beauty, they become quiet and less active, and show less interest in exercising intensely.[15,16]

Once adolescents reach high school they have a more mature way of thinking, study hard, and pursue their own ideals; however, the academic stress is more prominent at this age. Furthermore, they are socially inexperienced and cannot always solve the contradictions they face very well, and they may also have psychological problems.[17,18] According to the results of our investigation, academic stress can affect students' participation in physical activity. The results showed that most of the students feel stress as a result of their studies (27.9% very stressed, 33.1% above average stress, 30.9% average stress, and 4.0% below average stress stress). To achieve a premium graduation rate is the paramount task of the high school program in China due to the traditional Chinese exam-oriented education philosophy.[19] Young students experience high levels of tension, anxiety, fear, and frustration when they face the stresses of frequent testing, score ranking, and the ultimate pressure of the college entrance examination.[20] They also put pressure on themselves, which makes them sacrifice their leisure time to study. Consequently, their physical activity may become insufficient.[8,21] Our results confirm that most students spend less time on physical exercise and more time studying. This is unfortunate because students are actually eager to take part in physical exercise and show their youth and vitality, but because of academic stress and other social and family-related factors, they have chosen to quit exercise and instead engage in numerous problem sets and practice exams.[22]

Epidemiological studies have shown that obesity has a certain family genetic predisposition, is not only embodied biologically but also in the tendency to be physically active. For example, if the parents like sports, their children tend to have a common love of sports as they grow older. Many studies have shown that physical activity has an important role on weight control and improving the physical quality, and the formation of childhood physical activity patterns can continue into adulthood. These have important roles in preventing chronic disease. In the past 30 years, the global (including China) incidence of childhood obesity is rising rapidly. The reduction of physical activity and an increase of a static way of life become risk factors for continuing the problem of obesity. The present study showed that students who are overweight did less physical activity.

Stress has long been suspected to be interrelated to obesity, stress may play a major role in the development and maintenance of obesity in individuals who have an increased glucocorticoid exposure or sensitivity.[23] The results were consistent with previous studies that show an association between overweight/obesity and physical inactivity. According to the academic tress categories and learning time in this study, we demonstrated an inverse relationship between academic stress and physical activity. Although they know the benefits of physical activity, many Chinese students feel that they must spend most of their free time studying under the entrance examination system and are thus academically stressed; however, this study is cross-sectional and that cannot verify whether there is a causal association between academic stress and physical inactivity. Future research should explore whether these associations are maintained by observational and cohort studies.

Suggestions

The reason for adolescents' stress include "parents" and "teachers" in the study, they should be increased physical activity time at school to being integrated with changes in family lifestyle at home as well. Schools and family can have important role in preventing adolescent obesity by offering physical activities and physical education of health behavior management opportunities for students. Schools should offer or even require health education classes or provide health education lectures to expose students to knowledge about obesity, good eating habits, and the importance of physical activity to cultivate health awareness. The family should develop their personality and special skills through sports after school. Having more time and energy in their favorite sports should help students understand the importance of physical activities. If these messages can play to adolescents' subjective initiative, and teenagers participate in sports consciously, we can build a long-standing mechanism to improve the physical fitness of youth.

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Conclusion

This study described the time and the frequency of daily behaviors of high school students and revealed complex relationships between overweight/obesity or academic stress and physical activity levels among adolescents in China. More research is needed to investigate whether the associations of academic stress and physical inactivity is causal. Our findings highlight the importance of preserving time in youth schedules for physical activity every day and requiring physical education in schools as a strategy to increase overall physical activity levels and build a long-standing mechanism to improve adolescent health.

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Conflict of Interest

The authors declare there are no competing financial interests in relation to the work described. The authors declare no conflict of interest.

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