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Bicycling, health and weather-related disasters: Potential data to better predict risk

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China, the Bicycle Kingdom, has had some of the most outstanding bicycle infrastructure in the world. Though bicyclists are now fewer in China, much bicycle infrastructure remains. Bicycling should still be fostered because of the many health benefits, including lowered risk for obesity, diabetes, stroke, cancer and cardiovascular disease. Yet, due to high pollution levels, bicycling may not be as highly beneficial for health in certain cities. For issuing life insurance, it may be worthwhile to understand the health benefits from bicycling and the potential risks from pollution. For understanding weather-related disaster risk, it may be useful to know if a well-designed bicycle network exists for residents to routinely travel to maintain their health, to flee, or to effectively respond to emergencies.

This article reviews the health benefits of bicycling in different countries and China, health and pollution exposure while bicycling, and how cities are using bicycles to improve response to weather disasters.

Introduction

This article will review the health benefits of bicycling in different countries and China, health and pollution exposure while bicycling, and how cities are using the bicycle to improve their response to weather disasters. The article will also propose future research to add data to better predict risk in issuing life and weather-related disaster insurance. With these new data and initiatives associated with the bicycle, predicting risk could be easier and China could be an example for other nations.

The most common ways of engaging in physical activity include recreational activities, occupational work or active transportation, such as walking or bicycling.

Health benefits of bicycling

Physical activity includes recreational activities (eg swimming or playing tennis), occupational work (eg farming), or active transportation (eg walking and bicycling). Not everyone can engage in recreational activities because this involves discretionary time and often money to go to the pool or tennis club. Unlike labourers or farmers, many individuals now work in an office and sit for long periods. Individuals can burn calories if they walk to work or run errands, but research that involved 18 414 nurses suggested that of the nurses who walked slowly, weight gain was not controlled¹. If they walked briskly, weight was controlled but, in this study population, only 39% reported walking briskly compared with 50% who walked slowly. Bicycling also controlled weight and 48% of the nurses indicated that they bicycled. Bicycling may better control weight because the Metabolic Equivalent of Task (resting state is 1 MET) is highest for bicycling (about 8 METs) compared with slow walking (2.5 METs) or brisk walking (3.3 METs)².

The health benefits of bicycling are higher compared to walking.

Perhaps due to the additional exertion involved in bicycling compared with walking, the health benefits are higher. As cities vary in bicycle infrastructure and pollution, it is worthwhile to note the location of studies about bicycling. In India, bicycling, compared with using private or public transport or walking, was the most beneficial form of active travel to work for lowering the prevalence of overweight/obesity, hypertension and diabetes³. In Australia, compared to driving, men who bicycled to work were significantly less likely to be overweight or obese⁴. In studies in the Netherlands and Denmark, bicycling was associated with lower mortality and cardiovascular risk⁵, all-cause mortality⁶, and inversely associated with all-cause mortality and coronary heart disease if bicycling intensity was high⁷. A study in the US determined that the young men who bicycled vigorously for 45 minutes still had high levels of post exercise energy expenditure for up to 14 hours after bicycling⁸. A study that involved older men in Italy suggested that bicycling positively influenced their psycho-physical well-being⁹.

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One study found that children who bicycled were more physically and metabolically fit.

If a child or adolescent is overweight, the likelihood of early puberty, metabolic syndrome, type 2 diabetes, or, as an adult, obesity increases. If the child is then obese as an adult, their risk of some types of cancer and cardiovascular disease increases¹⁰. Thus, to improve longevity, it is important to be physically and metabolically fit as a child. Children in Denmark who bicycled had higher levels of cardiovascular fitness compared with walking or being driven¹¹. If children switched from not bicycling to bicycling, they were significantly more fit¹². According to one study, children who did not bicycle at baseline and who started bicycling were more fit and had a better glucose metabolism, cholesterol/HDL ratio, and CVD risk factor profile compared with those who did not bicycle at baseline or the end of the 6 year study¹³. Compared with walkers and car and mass transit users, bicyclists aged 15 to 19 years of age had greater aerobic power, endurance in abdominal muscles, and flexibility¹⁴. In a study in the US, children who rode a bike to school for 2 or more days a week were less likely to be overweight¹⁵.

Bicycling is beneficial for fitness, cardiovascular health, all-cause mortality, coronary heart disease morbidity, mortality, cancer risk and overweight/obesity.

Systematic reviews have been conducted of studies from many countries on biking and health. The conclusion was that bicycling was beneficial for fitness, cardiovascular health, all-cause mortality, coronary heart disease morbidity, mortality, cancer risk and overweight/obesity¹⁶. Health issues of obesity/overweight, hypertension, diabetes, cancer (increased risk with obesity), cardiovascular risk, fitness and psycho-physical well-being all are markers for a long life. Research conducted in Copenhagen followed 5106 healthy men and women between the ages of 21 to 90 over a period of 18 years. A weak association was found between the amount of time spent bicycling and risk of death from all-cause and coronary heart disease. Yet, the research found that the women who bicycled at moderate intensity lived 2.2 years longer and the women who bicycled at fast intensity lived 3.9 years longer. The men who bicycled at average intensity lived 2.9 years longer and the men who bicycled at a fast intensity lived 5.3 years longer⁷.

Research on health and bicycling in China

Research conducted in Hangzhou, China found that car owners were more likely to be overweight/obese.

Recent research conducted in Hangzhou, China indicated that, of those surveyed, 77% of the men and 72% of the women owned a car and, of these car owners, 43.8% bicycled each week¹⁷. Of Hangzhou's non-car owners, 62.2% bicycled each week. There was a statistical difference between percentages for overweight/obese (BMI 24) for individuals who owned a car (28.8%) compared with individuals who did not own a car (21.0%). Hangzhou is a wealthy city and also has the world's largest bicycle rental system¹⁸, wide cycle tracks with mature plantings between the cycle track and the road, and a policy in which cars with certain license plates are not allowed to be driven on specific days. These factors may help explain why, even though more car owners are overweight compared with non-car owners, the percentage for overweight/obese among car owners was 28.8% in Hangzhou. This was relatively low because the percentage for overweight/obese for all of China is 38.5% (45.0% males/32.0% females)¹⁹. In a study of eight provinces in China that included data from 1989 to 1997, odds of obesity were 80% higher for both men and women if a motor vehicle was owned in the household²⁰. In Hangzhou, where the government has enhanced and expanded the bicycle infrastructure as part of its efforts to be a low-carbon city²¹, car ownership was not as strongly associated with being overweight/obese.

A study in Jiangsu, China found that walking and bicycling were not beneficial for health.

Contrary to many studies about walking, biking, and health, a recent study in Jiangsu, China about active transport (walking and bicycling) indicated that walking and bicycling were not beneficial for health. The individuals who walked and bicycled had higher prevalence of cholesterol and risk of diabetes, while the individuals who did not walk or bicycle had lower risk of obesity and cholesterol²². Similarly, a systematic review of 15 studies of active transport (walking and bicycling) also found that walking and cycling may not be strongly associated with lowered obesity. However, in the studies that had separated walking from bicycling, researchers found that bicycling was associated with lower body weight²³.

Research on women in Shanghai found that bicycling provided higher benefits than walking.

As confirmation of this finding about the benefits of biking versus walking, a study that had been conducted on women in Shanghai found that exercise and bicycling were inversely associated with all-cause mortality, but walking for transportation was less strongly associated²⁴. To additionally confirm the finding about biking versus walking, the research conducted in the US on 18414 nurses showed that nurses who walked slowly did not control weight¹. In the Jiangsu study, which found that walking and bicycling were not beneficial for health, the authors defined active transport as walking and/or bicycling for more than 10 minutes, but did not identify the speed of the walkers, and defined a bicyclist as either riding a regular bicycle or an electric bicycle. Many e-bikes exist in China that are powered by a battery and that do not involve vigorous pedalling. The individuals involved in this measure of active transport in Jiangsu might not have been walking or bicycling for enough time, they might have been only walking, the walking speed may have been too slow, and the bicycle may have been an e-bike.

In one study, those who did not exercise were found to be at higher risk for cognitive impairment.

A study of 2030 Chinese individuals who were 70 years of age or older were followed for 36 months to assess cognitive impairment (CI). Of these individuals, 6.7% of the men and 22.2% of the women had CI at the end of the 3 years²⁵. If the participants had listed no exercise at baseline, their risk of CI increased twofold. In a study conducted in Tianjin, China with 2002 males and 1974 females aged 15 to 69 years of age, commuting and leisure-time physical activity were observed. Of the participants, 11% of the males and 7% of the females commuted by bicycle for more than 1 hour to and from work²⁶. Commuting by walking or bicycling for too much of the day may have downsides. If the men and women commuted by walking or bicycling for more than 60 minutes a day and also did leisure-time physical activity, they had the highest mean blood pressure and prevalence of hypertension compared with traveling by bus. This result may be because the long physical daily commute took a mental toll due to stress in rush-hour traffic.

Bicycling, health, and pollution exposure

Individuals who bicycle are also exposed to air pollution.

If all individuals bicycled only inside parks and thus far from vehicle exhaust, the health benefits would be the central measure. Instead, bicycling is a form of transportation and the main routes are often roads on which vehicles also travel, thus exposing the bicyclist to mobile source air pollution. As some cities have higher pollution compared with others, the location where a study was undertaken becomes relevant.

Researchers in Australia found that car occupants were more exposed to pollution than those commuting by bus, train, bicycle or walking.

A study conducted in Australia compared pollution exposure for five methods of commuting (car, bus, train, bicycle and walking) and suggested that car occupants were most exposed to pollution²⁷. Researchers in the Netherlands also compared pollution exposure, specifically particle number counts (PNC) and particulate matter < 2.5 μg $\text{PM}_{2.5}$, and found that PNC was 5% higher and $\text{PM}_{2.5}$ 11% higher within the car compared with the concentrations for the bicyclists²⁸. These studies only compared the environment and not breathing. Unlike the car occupant who is sitting still and at a resting state, the bicyclist is pedalling and thus has a higher ventilation rate. At a higher ventilation rate, the bicyclist can be taking more mobile source air pollution particles deep into their lungs compared with car occupants.

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Studies in Belgium and the Netherlands suggested that bicyclists were more exposed to pollution than motorists because their ventilation rate was higher.

Mobile source air pollution was compared in Sweden between car occupants and bicycle messengers, and though the pollution exposure appeared comparable between the two, the ventilation rate of the bicyclists was four times higher compared to someone at a resting state²⁹. A study in Belgium confirmed this measurement and suggested that the bicyclist ventilation rate was 4.3 times higher compared to individuals within the vehicles, exposing the bicyclists to more PNC and PM³⁰. In comparing exposure to Black Carbon (BC) in Belgium, the bicyclists were exposed to only half the BC exposure of car occupants, but when the ventilation rate was factored in, the bicyclists were exposed to BC at twice the level³¹. A study in the Netherlands indicated that bicyclists traveling along a route with heavy traffic had the highest exposure of PNC (46 600 particles/cm³), a measure higher when compared with being in a diesel bus (38 500 particles/cm³). When the ventilation rate was also factored in, that for bicyclists was twice that of the other modes; the bicyclists were the most exposed compared with riding diesel buses, electric buses, gasoline cars, or diesel cars³².

Bicyclists traveling during the morning commute are more exposed to pollution.

The time when the bicyclists are also traveling can increase their exposure. Individuals traveling to work by bicycle typically have no option but to travel when others are traveling and thus it is impossible to avoid exposure. A study in Belgium determined that the highest concentrations of ultrafine particles (UFP) are in the morning commute³³. Researchers in London confirmed this conclusion by studying Black Carbon (BC) as measured in the airway macrophages. Bicyclists traveling during the morning had 1.6 times the BC of individuals using public transit. Bicyclists were also commuting long distances, and thus were exposed for a longer time, and had 2.6 times higher concentrations of BC³⁴.

Exposure to mobile source air pollution can alter the heart rate.

Heart rate can vary depending on the pollution exposure when bicycling with many vehicles. A study conducted in Canada found that within the hours after bicycling in mobile source air pollution, the autonomic heart modulation can be altered³⁵. Subjects in Germany who spent time in cars, on public transport, on motorcycles, or on bicycles had higher risk of myocardial infarction (odds ratio 2.92) one hour after exposure to traffic pollution³⁶.

Bicyclists might be less exposed by taking alternate routes instead of sharing the road with multiple vehicles and riding between tall buildings.

Bicyclists might be less exposed if they can take alternate routes instead of sharing the road with multiple vehicles and riding between tall buildings. In a study conducted in London, bicyclists, plus walkers, bus riders, car riders and taxi riders in a street canyon were more exposed to PM_{2.5} compared with being on a less travelled back street³⁷. If the bicyclist could bicycle along an off road sea-wall environment, as in Vancouver, British Columbia, they would be far less exposed to PM_{2.5} and PM₁₀ but these alternate routes do not always take the bicyclist to their destination, including work³⁸. A study in Denmark advised bicyclists to not bicycle during rush hour and to also take the routes less travelled, but this alternative is not always feasible for getting to and from work or school³⁹. Boston bicycle routes were also compared for exposure to traffic-related air pollution and, again, paths that were a distance from the road and that had vegetation between the road and the bicyclists, offered the lowest exposure to pollution⁴⁰. A study of bicycle routes in Montreal indicated that having separated lanes, at least some distance from the tailpipe, could reduce exposure by 12%⁴¹. A comparative study of Portland's cycle tracks, ie barrier-protected and bicycle-exclusive paths between the moving cars/parked cars and the sidewalk – and bike lanes, ie painted lanes between parked and moving cars – suggested bicyclists on cycle tracks were less exposed⁴². Exposure to ultrafine particles did increase at intersections with signals as vehicles are idling at these locations.

Morbidity and mortality estimates from bicycling with pollution

Even though exposure to mobile source air pollution can negatively impact morbidity and mortality, studies in different countries have concluded that the physical activity of bicycling, even with pollution, improves health and extends life.

Being exposed to mobile source air pollution can negatively impact morbidity and mortality, but studies in different countries have concluded that the physical activity of bicycling, even with pollution, improves health and extends life. In a study in the Netherlands, the health benefits from bicycling were estimated to extend life 3 to 14 months, while the mortality effect from pollution can take away 0.8 to 40 days⁴³. Spain has recently been promoting bicycling, especially through the bicycle sharing system Bicing. Compared with individuals using cars, the estimated all-cause mortality relative risk associated with the physical activity from biking was 0.80. Instead of the typical number of deaths each year of 52.15, annual deaths were estimated to drop to 12.28 because of the increase in physical activity. The relative risk of all-cause mortality from pollution (less than 2.5 μm) was 1.002, suggesting the benefits from the physical activity were greater⁴⁴. A follow up study in Spain explored replacing car trips with the bicycle or public transport. If 40% of the car trips in Barcelona became bike or transit trips, 66.12 deaths were estimated to be avoided (1.15 more deaths from pollution, 0.17 more deaths from traffic fatalities, and 67.46 deaths avoided due to the benefits from physical activity)⁴⁵. A study in the US explored mortality, mobile source air pollution and the benefits from the physical activity involved in bicycling. If 50% of short car trips could be replaced by the bicycle, the yearly savings would be USD 3.8 billion per year in health care cost reduction and mortality that is postponed. In addition to mortality, measures included reductions in PM_{2.5}, asthma, chronic bronchitis, respiratory problems, cardiovascular problems and work-loss days⁴⁶.

Researchers in Denmark and Spain found that bicycling significantly lowers burden of disease.

Many studies have assessed lowered mortality with an increase in bicycling, but a study conducted in Denmark explored morbidity, or the burden of disease. Using the measure of disability-adjusted life years (DALY), the benefits from physical activity, and negatives from pollution exposure, an increase in bicycling would reduce the study population's burden of disease annually by 19.5 DALY. This estimate combines reducing the burden of disease from physical inactivity (76.0 DALY), increasing the burden of disease from pollution exposure (5.4 DALY) and increasing the burden from traffic accidents (51.2 DALY). When combined, the overall benefits from bicycling are lowered burden of disease⁴⁷. In addition to studying mortality in Spain with the introduction of more bicycling, researchers also assessed the impact on morbidity. If the bicycle and mass transit could result in 40% fewer long car trips, the result would annually be 44 fewer cardiovascular disease cases, 127 fewer diabetes cases, 30 fewer dementia cases, 16 fewer minor injury cases, 11 fewer breast cancer cases, 3 fewer colon-cancer cases, and 0.14 fewer major injuries. With lowered levels of PM_{2.5}, annually, there would be 7 fewer cases of low birth weight, 1 less cardiovascular disease case, 6 fewer pre-term births, and 1 less lower respiratory tract infection⁴⁸.

Pollution exposure in China, bicycling, and health

Few studies exist on bicycling and mobile source air pollution in China.

Studies that explore mobile source air pollution and health in the Netherlands, Denmark, Sweden, Canada, and the US do not compare with the pollution exposures in China. There are fewer studies on bicycling and mobile source air pollution in China, but a study of two Peking university campus gate employees who work by a heavily travelled road in Beijing may provide information. Exposure to high concentrations of PM resulted in oxidative stress with PAHs and metals being biologically active⁴⁹. The differences between this study and studies involving bicyclists were the two individuals were standing, and thus had a lower ventilation rate compared with bicyclists, and were at their station for 8 hours a day, and thus exposed for more time compared with bicyclists riding to and from work.

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It is difficult to assess the impact of bicycling in China on morbidity and mortality due to the lack of data on the ventilation rates of bicyclists.

Without specific studies carried out in China involving bicyclists in the cities with the highest concentrations of mobile source air pollution, it is difficult to determine changes in morbidity or mortality, especially without knowing the typical ventilation rate of bicyclists in China. Still, all humans benefit from higher levels of physical activity. The one study from China indicated that, compared with riding the bus, individuals who had to walk or bicycle for over an hour each day had prevalence of hypertension and high blood pressure, but the authors speculated that the route could have been stressful due to excessive traffic²⁶. Many cities in China have low levels of mobile source air pollution and cities in China with high levels are working to reduce the pollution. In all of the studies conducted in other countries, the health benefits far outnumbered the downsides of pollution exposure.

Stories have surfaced that bicycles have helped individuals flee when a weather-related disaster occurs.

Bicycling, risk assessment and weather-related disasters

Weather-related disasters, primarily as a result of climate change, are hard to assess for risk because the phenomenon is new and little peer-reviewed literature exists. Bicycling may appear to be completely unrelated to weather-related disasters and risk reduction, but stories in the trade market press suggest that the bicycle has been used by many individuals to flee when a disaster hits or has been used to help others during a crisis. If individuals in a community routinely bicycle, their overall health would be better, compared with a city of car owners, and the citizens would be more fit when responding to a crisis. The old model of evacuating a city using the highway system has, during many disasters, been proven untenable as roads quickly become clogged, cars run out of gas and are abandoned, and evacuation routes become impassable due to flooding, downed power lines, or downed trees. If a city has planned for the bicycle as part of its response to weather-related disasters, that city might be assessed for risk at a lower cost due to preparedness.

If a blackout occurs, trains and traffic sensors no longer work. Bicycling would be a better option than walking.

In August 2003, a blackout throughout New England and Canada impacted residents, including those in New York City. Though this blackout was not weather-related, a storm can also cut power. Once power is cut, trains halt and traffic sensors and cameras no longer work⁵⁰. Many can get home by walking but distances can be far, making the bike a better alternative if accessible.

In the aftermath of Hurricane Katrina in 2005, medics traveling by bicycle were able to offer medical assistance to residents.

After Hurricane Katrina hit New Orleans in 2005, the Algiers neighbourhood was one of the few that were not flooded, but there was no power or running water. Several days after the disaster, four medics arrived in the neighbourhood and measured blood pressure, tested for diabetes and asked about depression. These street medics were part of a health professionals group that included individuals who had worked at anti-war demonstrations. Their arrival preceded assistance from the Red Cross or FEMA. They travelled the streets by bicycle⁵¹.

Bicycles were also used after Hurricane Sandy in 2012 to help residents power cell phones.

In 2012, Hurricane Sandy hit New York City causing extreme flooding and a blackout. One enterprise, CSquat, fed the hungry by grilling food, but also set up a bicycle powered generator to charge cell phones, sometimes charging as many as 200 phones a day⁵². Bicycles have been described as "cockroaches of transportation" during such disasters as Sandy because with roads clogged, gas sold out, and mass transit halted, the bicyclist can still travel⁵³.

Bicycles were the only reliable source of transport after the 2011 earthquake and tsunami hit Fukushima, Japan.

The 2011 earthquake and tsunami that hit Fukushima, Japan and, in particular, the nuclear power plant, left people at work with no way to get home. The transit systems were shut down and roads that had not been destroyed became congested. The bike shops in Tokyo quickly sold out because the bike was the one means of guaranteed travel, especially for commuting trips in Tokyo that averaged 16 miles. Some who owned bikes could not get their bikes out of the parking machine that needed an electronic badge⁵⁴. The aftermath of the earthquake meant the nuclear power plant was jeopardised, but workers had to get to the plant to make repairs. One individual, a volunteer, was photographed wearing a nuclear suit and using a mountain bike to travel through the destroyed streets of Fukushima to help residents⁵⁵.

More transportation centres are calling for the use of bicycles in the aftermath of extreme weather events.

Transportation centres are now also seeing the wisdom of using the bike for disaster relief. The University of Minnesota Center for Transportation Studies ran a story in their recent newsletter about reducing the impact of extreme weather through resilient transportation systems. Information from the Center for Climate and Energy Solutions indicated that heat waves could curtail road construction, overheat vehicles, and cause brownouts. Railroad tracks could buckle, airports could limit flights, and road surfaces could be compromised through heat, flooding, or landslides. The call was for preparedness in transportation, but also for post-disaster planning⁵⁶. For a crisis, a city could have planned above-flood water bicycle evacuation routes, access to one's own bicycle if the power is shut down, bicycle storage that is not in the basement in a flood prone area, and solar power light posts with outlets for recharging smart phone and bicycle lights.

Planning for the use of bicycles could be an indication of weather-related disaster preparedness.

An indication for weather-related disaster preparedness by a city could be the number of plans for disaster. In Portland, Oregon, bicyclists, especially those who own cargo bikes, have been training to haul supplies in the event of a disaster⁵⁷. With ambulance cargo bikes, they could even operate an ambulance service if roads are shut down. Having a fleet of trained riders, well-equipped bicycles, and a communications cell phone system powered by solar or generators getting power from pedalled bikes could be the most viable alternative when all roads are shut down. Having trained bicyclists guide citizens as they flee the city on their own bicycles to higher ground shelters would be a better alternative to clogged roads and abandoned cars.

Future research for bicycling and new risk assessment measures

Life insurers and subsequently policyholders may benefit if the census and health surveys collected information about bicycling to work.

Based on the findings from the literature, life insurance providers and subsequently policyholders may benefit if the census and health surveys collected information about bicycling to work, including the amount of time a person spent biking each week and bicycling intensity. This information would help in determining morbidity but also mortality. The new census and health survey data could be coupled with the pollution measurements for that city to better predict risk and longevity. The bicycle infrastructure and congestion of bicyclists could also be studied in the applicant's city to determine the bicycling speed, ventilation rate, and stress from traffic. Key measures would be if the bicyclists are pedalling in traffic or on their own plant-separated cycle track that is somewhat removed from mobile source air pollution.

To determine the resiliency of a community in order to issue weather-related insurance, it may be useful to determine if a community has a high ground bicycle network.

For determining the resiliency of a community in order to issue weather-related insurance, especially with the vagaries of climate change, it may be useful to determine if a community has a high ground bicycle network for movement within the community and for fleeing the community. Determinations could also be made on whether this network might be prone to a washout or landslide and to design alternate routes out of the city. Networks of roads could be similarly studied, but in a disaster the roads most often become clogged due to cars which run out of gas or are abandoned.

A bicycle network would also better guarantee that a higher percentage of the population was physically fit and better able to function during a disaster.

Having a bicycle network would also better guarantee that a higher percentage of the population was physically fit and better able to function during a disaster. Percentages of individuals who bicycle in the community and who own working bicycles could also be assessed. In the event of a power outage, knowing that the vast majority of the bicycles could be accessed without power would be essential. If all of the bikes are in cages for which swipe cards are needed for entry, none of the bikes could be used unless wire cutters were available to cut through the chain link fence walls.

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Having a plan in place for the use of bicycles could signal disaster preparedness.

Having a cadre of bicycle responders, especially riders with cargo bikes, would signal preparedness for disasters. Having bikes that act as generators would mean cell phones could be recharged. Knowing several bicycle generators are scattered throughout the community would be ideal. Questions could be asked including if the bicycle responders could communicate and assemble themselves without power or active phone lines. If medics arrived, additional bicycles would have to be available that could be used as ambulances, to carry water, or as transportation if equipped with baskets for carrying supplies. If a city had a bike share system, the system could have a turnkey to allow all the bikes to be available to the public or at least available to ride for share members.

Further research is needed in China to collect data on bicycling habits, bicycling infrastructure and the use of bicycles in the aftermath of weather-related disasters.

Research could be conducted to determine what questions about biking are currently asked on census and survey forms in China and what would be necessary to add questions to the census forms to collect data on hours spent biking each week and speed of bicycling. Research could also be conducted in several cities in China to determine the existing bicycle infrastructure in order to better predict health (including the ability to bicycle without stress and away from pollution as well as pedal fast). The infrastructure and bicycle programmes could be studied in China to measure emergency preparedness and willingness to improve the bicycle infrastructure and initiate programmes. By providing this new information to assess life insurance risk as well as weather-related risk, cities might be encouraged to improve their bicycle infrastructure and introduce programmes for weather-related disaster response. The work of the insurance company could help communities extend the life of residents and avert disasters.

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