Economics, Law, and Institutions in Asia Pacific

Makoto Yano
Fumihiko Matsuda
Anavaj Sakuntabhai
Shigeru Hirota *Editors*

Socio-Life Science and the COVID-19 Outbreak

Public Health and Public Policy

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Economics, Law, and Institutions in Asia Pacific

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Foreword by Nagahiro Minato

COVID-19 first recognized in China in the winter of 2019 was rapidly spread throughout the world in a matter of months, and WHO declared the pandemic infection in 11 March 2020. By as early as February 2020, the pathogen causing serious pneumonia in a portion of infected people was identified to be a novel coronavirus, SARS-Cov-2, and it soon became evident that the virus was highly contingent directly from human to human. Facing with rapid accumulation of medical/epidemiological facts, however, the countermeasures of many governments varied markedly, depending on their political systems, economic status, major religions, and historical lifestyles of people. More notably, the attitudes towards the pandemic appeared quite different among individuals even in the same society. Thus, the question of how society should cope with the pandemic seems to present a typical subject of so-called post-normal science proposed by S. Funtowicz and J. Ravetz decades ago, where "facts are uncertain, values in dispute, stakes high, and decision urgent".

For years before this pandemic, Dr. Makoto Yano at Kyoto University has been appealing the importance of evidence-based decision-making in the fields of practical policy and economy, in much the same way as evidence-based medicine that widely prevailed in clinical practice during last decades. Meanwhile, Dr. Fumihiko Matsuda has been conducting a unique health cohort study involving 10,000 residents in Nagahama City, where his team was accumulating numerous bio-information including genomes, metabolomes, and proteomes of individual residents along with their health/disease records longitudinally for years. The comprehensive Nagahama health cohort was considered to provide an ideal basis for a pilot study to substantiate Dr. Yano's contention, and indeed the collaborative research between the two groups turned out to be highly productive, opening a new arena for socio-biomedical studies.

On facing the current COVID-19 pandemic, it was soon recognized that the comprehensive approaches combining social and natural sciences were crucial to seek for the best decision-making at all levels for coping with this disaster. Although emerging scientific unknowns should be addressed as quickly and systemically as possible, rational guidelines, with a scientific basis, on how individuals and society should behave to combat the disaster are needed. This study is part of the recent progress in the comprehensive socio-life scientific approaches towards the COVID-19 pandemic, and I believe that such studies should provide us important practical clues not only to overcome the current pandemic but also to be prepared for other future upheavals.

Kyoto, Japan
June 2021

Nagahiro Minato
President of Kyoto University

Dr. Nagahiro Minato graduated from Kyoto University School of Medicine in 1975 and studied as a research associate with Prof. B. R. Bloom at Albert Einstein College of Medicine in New York from 1977 to 1980. He received his doctorate in medicine (MD, Ph.D.) from Kyoto University in 1981. In 1992, he was appointed as a professor of Immunology and Cell Biology at Kyoto University Graduate School of Medicine and served as the dean from 2011 to 2014. He has published more than 220 original papers on immunology and cancer and first proposed PD-1 checkpoint blockade cancer immunotherapy with Dr. Tasuku Honjo, a laureate of 2018 Nobel Prize of Physiology or Medicine. He is currently the president of Kyoto University.

Foreword by Haruhiko Ando

Bienvenu and welcome to this new research endeavour, an unprecedented, international and interdisciplinary research project undertaken between the Institut Pasteur, Kyoto University, and the Research Institute of Economy, Trade and Industry (RIETI). What a fantastic adventure Profs. Makoto Yano and Fumihiko Matsuda are embarking on. It is a great honour to write this message of encouragement for this very promising research project.

RIETI, a Japanese national research institute affiliated with METI, was established in 2001 as a new independent administrative agency when the Japanese central government undertook structural reforms. The main founders were the late Professor Masahiko Aoki (Stanford University), Mr. Sozaburo Okamatsu (Former Vice-Minister of MITI), Mr. Nobuo Tanaka (Former Director-General of International Energy Agency), and Mr. Koji Matsui (Former Deputy Chief Cabinet Secretary), among others. I was also a founding staff member. Then, RIETI aimed to advance the world's top-class economic research, gathering the brightest brains and eminent voices from inside and outside of Japan. Now, RIETI is ranked as the top economic research institute in this country.

Professor Yano has had a long career of rich teaching experience in first-class universities such as Kyoto, Keio, Yokohama National Universities in Japan, and Cornell University in the USA, chaired the Japanese Economic Association (JEA) during 2008–2009, and then took the position as the fourth president and CRO of RIETI in 2016 and the fourth chairperson after 2020. While Prof. Yano initially maintained a relatively modest and conservative leadership style at RIETI, prioritizing institutional harmony or *Wa* in Japanese, the sudden introduction of three brave staff, "les trois Mousquetaires", Ms. Akemi Mogi, Mr. Sotaro Okubo, and Ms. Sumie Tamiya, allowed him to expand his vision and strongly encouraged him to lead interdisciplinary research activities for the coming fifth term of RIETI for which he was assumed to become the next chairperson. Actually, that was what was needed to open the doors towards this important socio-life cientific research project.

As a sidenote, a friend of mine, who is a leading Japanese venture capitalist and who has supported many promising startups and tried to establish a real Japanese "Eco-System for value-creation", long ago told me that the most important and fundamental skill for a venture capitalist is “human understanding”. I sincerely hope that this new, promising project of collaboration between these three internationally famous institutions will contribute not only to a better understanding of COVID-19 and preparations for the next unknown pandemic diseases, but also to a fundamental “human understanding” including social structures, behavioural changes, and ultimately what it means to be a human being.

Despite the fact that scientists have unravelled the mystery of the entire human genetic code, we still do not know what it means to be a human being. The mysteries that lie within us are as great as the mysteries of dark matter and energy that are said to make up the majority of the universe. This book presents many interdisciplinary socio-life scientific discussions by various authors with wide-ranging approaches and mindsets regarding this pandemic and other social issues. It demonstrates the value of research for scientific progress and perhaps offers some clues to tackling further unknown frontiers towards better human understanding.

There is a Japanese saying, “whenever three gather together, you have the wisdom of Manjushri”. It reminds me of Schumpeter’s idea of *neue Kombination*, which sees the key to innovation, and I sincerely hope this “trilateral” international Socio-Life Science research will be able to provide us with help in developing future innovation that will provide direction for all human beings.

Tokyo, Japan
June 2021

Haruhiko Ando
Vice Chairman, RIETI

Haruhiko Ando is the vice chairman of the Research Institute of Economy, Trade and Industry (RIETI). Specializing in law and quantum chemistry at the University of Tokyo, he joined the Ministry of International Trade and Industry (currently the Ministry of Economy, Trade and Industry (METI)) in 1985. While serving as the director for Economic Fiscal Management of the Cabinet Office and the director for Hydrogen and Fuel Cells, he planned several cutting-edge national laboratories for FCH2, PV, and LIB. Subsequently, he served as Director for both renewable energy and circular economy, the counsellor of the Cabinet Office and Cabinet Secretariat, at which he drafted the Science and Technology Basic Plan and the Intellectual Property Strategic Programme, and the deputy director general for International Projects. He was seconded as the director for Energy Policy at Hitotsubashi University. Since 2004, Ando has been a visiting professor at the University of Electro-Communications. He was a founding member of RIETI in 2001 and, among others, co-edited a Japanese volume *Modularization* with Prof. Masahiko Aoki of Stanford University, a founder and the first president of RIETI.

Preface

In this book, we propose research on what we call socio-life science. By socio-life science, we mean the field of research to study humans in a manner in which both social and life scientific factors are integrated. Humans are living creatures. They are also social creatures. Why a particular person takes a particular action under a particular circumstance and/or is in a particular state of health can never be understood fully without knowing both his biological traits and the social scientific environments in which he lives. We envision socio-life science to give a deeper and more integrated understanding on human behaviour and human health.

With this belief, Fumihiko Matsuda, Shigeru Hirota, and Makoto Yano, three of the four editors of this book, initiated a joint research project at Kyoto University in 2015, building a panel data (or cohort data) targeting the residents of Nagahama city. The data encompasses an individual's basic biomarkers, medical history, genomic features, economic and social characteristics, and behavioural patterns (the Nagahama socio-life science data). Matsuda is a life scientist, who has been heading the Center for Genomic Medicine at the Graduate School of Medicine, Kyoto University. Hirota and Yano are economists, who were affiliated with the Institute of Economic Research, Kyoto University, at that time; currently Hirota is a faculty fellow at the Research Institute of Economy, Trade and Industry (RIETI); Yano is its chairperson. The bridge between social scientists and life scientists was formed by Prof. Nagahiro Minato, the then vice president and executive director, the current president of Kyoto University, who is himself a renowned medical scientist/doctor. RIETI joined this collaboration in 2020 when Yano assumed its chairpersonship.

This book aims to show what could, and can, be achieved through the type of interdisciplinary project initiated at Kyoto University. One important product of this project is the newly formed three-party collaboration between Institut Pasteur, Kyoto University, and RIETI. Facing an early stage of the COVID-19 outbreak, around February 2020, Yano and Matsuda started to discuss a possible socio-life scientific collaboration between Kyoto University and RIETI. As the outbreak worsened, we invited Anavaj Sakuntabhai, the third editor of our book, who heads the functional genetics of infectious diseases structure at Pasteur, with which Matsuda has kept a long research association. This has broadened the scope of the collaboration, and of this book, to which 29 authors with different sets of expertise contribute one way or another. These people include medical scientists/doctors, epidemiologists, economists, anthropologists, a political sociologist, a geographer, a historian, businessmen, a computer engineer and a policy-maker. Facing the COVID-19 outbreak, our authors all see the importance of building socio-life science.

The book consists of three parts. In the first part (Part I. Socio-Life Scientific Approach to COVID-19), we present the current studies on the COVID-19 pandemic from many different viewpoints—medical, political scientific, epidemiological, anthropological, sociopolitical, informational, and socioeconomic. Although these studies take different approaches, they all agree on the importance of socio-life science in the face of COVID-19; all the studies emphasize the role of behavioural change and governmental policy to fight against the huge threat on our life.

Our initiative is built on the Nagahama Prospective Genome Cohort for Comprehensive Human Bioscience (the *Nagahama Study*). The *Nagahama Study* was started at the Graduate School of Medicine, Kyoto University, in 2007 under Fumihiko Matsuda's leadership and, subsequently, joined in 2015 by Makoto Yano to cover social scientific aspects in the cohort data. The scope of this data is explained in the second part of this study (Part II. Socio-Life Scientific Data Building). From the social scientific viewpoint, the Nagahama data aims to address the fundamental question as to what holds a society together. For this purpose, the data is designed to measure the amount of social capital an individual holds and to capture its determinants. Facing the COVID-19 outbreak, we are currently building data on behavioural change, the importance of which is highlighted in Part I.

The potential use of our data covers many issues on human behaviour and human health. Because we are still in the middle of compiling data, unfortunately, we cannot present our results at this stage. To show the potential use of our data, instead, we present in the third part of this book (Part III. Socio-Life Science on Public Health and Behavioural Change) several state-of-art studies that could be extended with our data.

The chapters presented in Part I are concerned with the COVID-19 outbreak. In Chap. 1, Sharon Peacock (clinical microbiology), CBE, the executive director of the COVID-19 Genomics UK (COG-UK) consortium, explains in depth the variants of SARS-Cov-2 that are threatening our effort to contain the outbreak. She stresses the importance of national surveillance and urges to build a global network of sequencing capabilities and data-sharing platforms, which are not currently in place. This chapter is based on the excellent presentation at our 17 April 2021 workshop, the First RIETI-CGM-IPJO Joint International Workshop on Socio-life Science: Public health and COVID-19 outbreak, jointly organized by the three institutes. In Chap. 2, Makoto Yano (economics) focuses on the early spread of COVID-19 in the US state of Florida and shows the importance of political leaders and social learning in leading people to change their behavioural patterns and to engage in self-protection. In Chap. 3, Richard Paul, Olivier Telle, and Samuel Benkimoun (epidemiology) investigate how the use of Facebook data makes it possible not only to capture the impact of lockdown on human mobility but also to assess how changes in mobility contribute to the spread of the virus. In Chap. 4, by using an anthropological method, Leonardo Heyerdahl, Benedetta Lana, and Tamara Giles-Vernick (anthropology) explain the harmful content of the online informational ecosystem and containment efforts through which they identify factors contributing to public interpretation and offline practices during the COVID-19 pandemic. In Chap. 5, Adrienne Sala (sociology) and Rémi Scoccimaro (geography) investigate Japanese policy on the COVID-19 epidemic in conjunction with a socio-spatial analysis and find that the local authorities have been effective and responsive in the epidemic management, which has sometimes generated confrontation with the national government. In Chap. 6, Masaki Yamamoto, Yasufumi Matsumura, and Miki Nagao (medicine) describe the type and selection of serological antibody testing for COVID-19. They report that of 1737 healthcare workers in Kyoto, only eight people were seropositive for tests conducted in July and August 2020, in which the pandemic had not yet spread into the Kyoto region. Many of the studies presented here capture intuitively straightforward effects of COVID-19. For this reason, we believe, they are all the more important.

In Part II, we explain the ongoing project to build the socio-life scientific data at Kyoto University and RIETI. In Chap. 7, Kazuya Setoh and Fumihiko Matsuda (medicine) explain the *Nagahama Study*. The survey was started in 2007 by Matsuda and his colleagues at the Graduate School of Medicine. From the survey, unique cohort/panel data has been compiled that covers the genome sequences and biomarker records of ten thousand individuals who resided and continues to reside now, in the city of Nagahama located about 50 km northeast of Kyoto, and has produced a number of forefront papers. Setoh and Matsuda explain this project and main research papers that have come out of this project. In Chap. 8, Makoto Yano, Shigeru Hirota, Masato Yodo (economics), and Fumihiko Matsuda (medicine) explain the social scientific addition to the original *Nagahama Study*, which is to address what holds a society together. In order to study this issue, the main focus of the questionnaire is set on social capital. The chapter explains the social science questionnaire and describes summary statistics in the first socio-life science survey in 2016. In Chap. 9, Shigeru Hirota (economics), Kazuya Setoh (medicine), Masato Yodo, and Makoto Yano (economics) explain the COVID-19 survey that RIETI and Kyoto University jointly conduct in Nagahama and Kyoto. This social scientific side of this survey focuses on behavioural change in the COVID-19 pandemic. The life scientific side of the survey focuses on the results of antibody tests based on the new COVID-19 antibody test kit that the Pasteur Institute has just developed. The data focuses on the serious outbreak of COVID-19 started in the spring of 2021, and, for this reason, unfortunately, the survey results are not yet ready for analysis.

One important issue faced by researchers building data covering both human health and behaviour is data sharing. By data sharing, we do not simply mean the sharing of data among researchers, which is highly important for us researchers. However, more important is the sharing of data between researchers and survey participants. We have realized the importance of the latter issue while preparing to build data on human behaviour and COVID-19 antibody development. At the beginning of the COVID-19 outbreak, in Japan, COVID-19 infection was a highly sensitive issue; it was feared that those contracted SARS-Cov-2 might somehow be ostracized in traditional regions. In these circumstances, we have discovered that there is not easy way to inform survey participants of COVID-19 antibody test results. In Chap. 10, Chris Dai (computer engineering), Tadaaki Chigusa (business), and Makoto Yano (economics) study the application of blockchain technology to address this issue, creating a secure database that makes sensitive research data available for both a research community and survey participants.

In Part III, we show how our data might be used. For this purpose, we present several forefront studies on broader issues on social epidemiology, elderly health care, and behavioural change. Although these studies are not based on the Nagahama data, they show how our data could be used to address various socio-life scientific issues. In Chap. 11, Akiyoshi Senda, Anavaj Sakuntabhai, Fumihiko Matsuda (medicine), and Richard Paul (epidemiology) investigate the dengue fever outbreak in the Tokyo region during the 2010s, which casts a new light on how epidemic might spread in a region with no previous records. In Chap. 12, Yoichi Sekizawa, Yoko Konishi (economics), and Hiroshi Ikari (business) study the factors that may contribute to the development of "mild lifestyle-related diseases" or, more specifically, hypertension, dyslipidemia, and diabetes mellitus. This research is a good example showing certain lifestyles matter, as one gets older. In Chaps. 13 and 14, leading Japanese economists on behavioural change investigate the design of a mechanism to achieve desirable behavioural change, which is a central issue during the COVID-19 outbreak. In Chap. 13, Kazuo Nishimura and Tadashi Yagi (economics) show the importance of ability to change one's behaviour in the determination of life satisfaction. In Chap. 14, Kazuo Nishimura, Tadashi Yagi, and Dai Miyamoto (economics) study the effect of education policy on behavioural change by focusing on science education.

The collaboration among chapter authors of this book started on 16 and 17 December 2020, in the online workshop "The COVID-19 Outbreak and Public Health Issues: an interdisciplinary approach", hosted by Anavaj Sakuntabhai and Bernard Thomann of Institut français de recherche sur le Japon à la Maison franco-japonaise. Many of the chapter authors participated in the workshop. On each day, after the presentations of papers, we had a long discussion session. Through the exchange of opinions by researchers with many different specializations, we were able to confirm the importance of socio-life scientific research. In Chap. 15, Anavaj Sakutabhai (medicine) and Bernard Thomann (history), the hosts of the workshop, summarize the discussion at the workshop to share with readers.

This book reflects the research activities at the Research Institute of Economy, Trade, and Industry (RIETI) to contribute to the integration of natural and social science research, one of the main themes for RIETI's fifth planning period, 2020–2023. Towards this goal, RIETI has published in 2020 a research volume, *Blockchain and Crypto Currency* (Yano et al., eds), in the Springer book series, "Economics, Law and Institutions in Asia Pacific". The present volume, included in the same series, is to show the RIETI activities in socio-life science. Over the last 15 years, before the COVID-19 pandemic, Japanese society has experienced several major crises, including the 2008 Global Financial Crisis and the 2011 Great East Japan Earthquake. Even more serious for Japan is the 30-year long stagnation, out of which the country has not yet emerged. It appears that, behind these problems, the gaps between social science and natural science and between culture and technology have been at work. The Global Financial Crisis has often been attributed to the mechanization of financial transactions, which became common with the rapid advancement of computer technology. The nuclear accident at the Fukushima power plant created a huge problem for Japan. Subsequent investigations have revealed that the accident was worsened by many social scientific factors (see *Independent Investigation Commission on the Fukushima Nuclear Accident. 2014. The Fukushima Daiichi Nuclear Power Station Disaster: Investigating the Myth and Reality*, ed., Bricker. New York: Routledge). The 30-year long stagnation has long been attributed to the weak innovation (Fensom, 2012, "Japan's lost art of innovation", The Diplomat, October 19, 2012). To avoid another crisis and to get out the stagnation, it is critical to bridge social science and natural science. We hope that our research project, explained in this book, would solidify this bridge.

In carrying out our joint research project and putting this book together, we are indebted to a large number of friends and organizations. We are indebted to Institut français de recherche sur le Japon à la Maison franco-japonaise, which hosted our first meeting on 16 and 17 December 2020, on the subject covered by this book. The editors are indebted to Mr. Haruhiko Ando, the vice president of RIETI and a career official of the Ministry of Economy, Trade and Industry, which oversees the RIETI activities, and to Prof. Nagahiro Minato, the president of Kyoto University. Mr. Ando has been instrumental in putting together our joint research project between RIETI and Kyoto University and provided a number of important suggestions towards the joint project. As is pointed out above, without President Minato's initial advice, constant help, and encouragement, our joint project would have never materialized. We are also grateful to a number of staffs at RIETI and Kyoto University who put together a contractual arrangement to create a joint project, in particular, Mr. Yoshiyuki Sugiura, the director in charge of research, and Ms. Maya Kimura, the vice director, at RIETI, who carefully structured the contract for the completely new type of research project for RIETI. We are indebted to Mr. Masataka Saburi, the director in charge of communications, Mr. Yoichi Sekiguchi, the coordinator for communication, and Ms. Toko Tanimoto, the vice director, who helped us organizing workshops and making public announcement. We are also grateful to Ms. Chieko Ishihara, Mr. Takehiro Watanabe for always keeping in touch with Springer. The editors are grateful to Mr. Nobuaki Tsujii, President, and Ms. Teruyo Miyagawa, the secretary general of the NPO Zero-ji Health Promotion Club in Nagahama, for their valuable efforts in initiating the socioeconomic behavioural questionnaire survey of the Nagahama study. We are grateful to Ms. Juno Kawakami of Springer, who helped us put together this book, for her patience and constant encouragement.

Makoto Yano expresses many thanks to Prof. Atsushi Nakajima of Niigata Prefectural University, who led RIETI during the fourth planning period of RIETI (April 2016–March 2020) as the chairman. Before leaving his position at RIETI, Prof. Nakajima selected the integration of natural and social science research as one of the main themes for the fifth planning period at RIETI. This book is one of the products in pursuit of the target that Prof. Nakajima set for RIETI. Yano is deeply indebted to Ms.

Akemi Mogi, Mr. Sotaro Ohkubo, and Ms. Sumie Tamiya, the members of the fifth plan drafting team at RIETI, and to the members of the Industrial Structure Policy Division, METI, in particular, Mr. Tomoshige Nambu, the division chief, Mr. Shozo Maeda, the vice division chief, Mr. Koichi Kaneko, the vice division chief, and Mr. Kai Fukunaga, the section chief, for their help designing a wonderful plan for RIETI's fifth term; without their eagerness to set a target as high and attractive as possible, this book would have never been born. Yano also expresses many thanks to his secretary, Ms. Waka Kikuchi, and the head of the chairman's office, Ms. Keiko Harada, for their devotion. The other theme for the fifth plan Prof. Nakajima set is evidence-based policy-making. Yano is grateful to Prof. Masayuki Morikawa, the president and the chief research officer of RIETI, who leads research in pursuit of this target, for his devotion to keep RIETI's high research standard. Yano wishes to thank Mr. Masahiko Nakazawa of the Ministry of Finance, who was seconded to Kyoto University as a professor. Their collaboration led to the book *Naze Kagaku ga Utakasa ni Tsunagaranai noka* (*Why has Science Failed to Contribute to Economic Growth*) (Keio University Press, 2015), which argues to bring down the divide between social and natural science. Yano wishes to thank Mr. Jun Hamano, a former vice minister of Cabinet Office, Mr. Takao Kuramochi, a former director general for science, technology, and innovation policy of Cabinet Office, President Nobuaki Kawakami at Miyagi University, a former director general, the science and technology policy bureau, the Ministry of Education, Culture, Sports, Science and Technology, Prof. Kazue Kurihara, Tohoku University, and Prof. Kiyoshi Yoshikawa, Kyoto University, for their help and encouragement, which has led to this book. Yano is grateful to Profs. Satoshi Mizobata and Yoshihiko Nishiyama at the Institute of Economic Research Kyoto University for supporting the joint project between RIETI and Kyoto University.

Fumihiko Matsuda first would like to thank Nagahama residents who kindly agreed to participate in the *Nagahama Study*, the City of Nagahama and NPO Zero-Ji Health Promotion Club for their valuable support to make the study most successful. He would like to thank all the collaborators who joined the study, especially the 23 departments of the Kyoto University Graduate School of Medicine, for their continuous cooperation. The Center for Genomic Medicine staff members has made their maximal efforts to manage the health check, conduct genomic analysis, and construct the information infrastructure for data registration and bioinformatic analyses. He would like to express sincere gratitude to Prof. Taka-Aki Sato and Dr. Kazuhiro Sonomura of Shimadzu Co. for their long-standing collaboration in the multi-omics analysis. The *Nagahama study* is supported in part by the University Grant of the Ministry of Education, Culture, Sports, Science, and Technology, Japan, and Takeda Science Foundation.

Anavaj Sakuntabhai would like to thank Profs. Makoto Yano and Fumihiko Matsuda for inviting him to join this socio-life science initiative. He would like to thank his colleagues from Institut Pasteur, Paris, Dr. Richard Paul and Dr. Tamara Giles-Vernick, who broadened his view on environmental and social factors in determining spreading and outcome of diseases. Both contribute to the conference and chapters of this book. He would like to express his gratitude to Prof. Mark Lathrop, his

former Ph.D. supervisor from University of Oxford, who is still supporting him for connection with international scientific network. Professor Lathrop helped inviting Prof. Sharon Peacock, the executive director of the COVID-19 Genomics UK (COG-UK) consortium. He appreciates very much the participation of Prof. Peacock, who gave an outstanding talk on COVID-19 variants, and has contributed a chapter of the book. Lastly, he would like to thank Olivier Telles, Akiyoshi Senda, his former postdoctoral fellow and student, respectively, whose excellent works are published in this book.

Shigeru Hirota would like to thank Ms. Tomomi Inada, a member of House of Representatives and a former minister of State for Regulatory Reform. His experience as an executive secretary to the Minister has been extremely beneficial to his career, which spans bureaucracy and academia. Hirota is also indebted to Prof. Satoshi Mizobata, Former Director, and Prof. Yoshihiko Nishiyama, the current director of Kyoto Institute of Economic Research, Kyoto University. They provided various supports to Hirota during his secondment to the institute as a specially appointed professor from 2014 to 2017 and even after his return to the government. Hirota would also like to express his gratitude to Ms. Fumiko Ihara, a secretary of the Institute, for her accurate handling of various administrative matters including those related to the *Nagahama study*.

Tokyo, Japan	Makoto Yano
Kyoto, Japan	Fumihiko Matsuda
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Kyoto, Japan	Shigeru Hirota
June 2021	

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Editors and Contributors

About the Editors

Makoto Yano is the chairman of the Research Institute of Economy, Trade and Industry (RIETI); he is also a specially appointed professor at Kyoto University and Sofia University. He is an internationally known researcher who has made a number of substantial contributions in international trade, and especially on economic dynamics. In a series of recent research, he proposes market quality theory, addressing various problems in modern economies, including the financial market crisis since 2008 and the recent nuclear accidents in Japan, from the point of view of market quality. Concerning quality of competition, quality of information, and quality of products, market quality is defined as an index jointly determined by the efficiency of an allocation and the fairness of the prices that are achieved in a market. An influence of his theory can be seen in Krishnendu Dastidar's book, *Oligopoly, Auctions and Market Quality* (2017), included in the same Springer book series as the present volume. He received a BA in economics from the University of Tokyo in 1971 and a Ph.D. in economics from the University of Rochester in 1981.

Professor Fumihiko Matsuda obtained his Ph.D. from Kyoto University Graduate School of Medicine in 1990 under Prof. Tasuku Honjo and continued his research with him until 1998. Throughout this period, his work is the organization of the human immunoglobulin heavy chain variable region (VH) gene locus. In 1998, he joined Centre National de Genotypage (CNG) in Evry, France, as the head of gene identification. During his stay at CNG for ten years, he played a significant role in numerous comprehensive genetic analyses of multigenetic disorders. Since holding a joint appointment as a professor of the Center for Genomic Medicine at Kyoto University in 2003, he focused on the trans-ethnic genetic studies of human diseases. Since 2012, he has led an international collaboration with McGill University in genomics and contributed to establishing an International Joint Degree Programme in Genomic Medicine between Kyoto and McGill. The programme was initiated in April 2018. Since 2016, he is currently the scientific coordinator of Pasteur-Kyoto

International Research Unit for Vaccinomics. Also, he has served as the research director of RADDAR-J, a nationwide rare disease platform programme in Japan supported by AMED since 2017.

He has consistently devoted himself to researching human genetics and genomics by integrated omics analysis of human disorders through various positions he has engaged. He has experience working in France for ten years with international collaborators. He is also promoting international collaborations with Asian countries, including China, Korea, and Thailand, as well as with France, Canada, and the UK.

He is Chevalier de l'Ordre National du Mérite.

Anavaj Sakuntabhai MD, D.Phil. is a medical doctor from Thailand. After his Ph.D. on human molecular genetics at the Wellcome Trust Centre for Human Genetics, University of Oxford in 2000, he joined the Institut Pasteur to develop a programme on genetics of infectious diseases. He created the research unit of Functional Genetics of Infectious Diseases at Institut Pasteur in 2010 focusing on genetic susceptibility to dengue infection. He received Prix Dusquense in 2016 and i-Lab Grand Prix award from the French national challenge of innovation organized by the French Ministry of research in 2020 for the development of new pentavalent dengue and Zika T cell vaccine. He coordinated European FP7 project on Dengue Framework for Resisting Epidemics in Europe (DENFREE). He was involved in investigating two recent global outbreaks of infectious diseases, Ebola and Zika. Currently, he is a coordinator of the Pasteur International Centre for Research on Emerging Infectious Diseases (PICREID)—supported by the NIH. The project is implemented in West and Central Africa and Southeast Asia, linking large observational multicentre cohort studies with basic scientific research and leading to increased preparedness for new epidemic threats in the region. Recently, he was appointed as the director of Institut Pasteur Japan office to establish a transdisciplinary network on emerging infectious diseases between Japan, France, and countries in the Indo-Pacific region.

Shigeru Hirota is a professor at Kyoto Sangyo University and a faculty fellow of RIETI. Directly after graduating with a BA from the University of Tokyo in 1992, he joined the Cabinet Office and held positions in charge of analysing the Japanese economy, regional economies, and compiling national and regional statistics. He was the director of the Department of National Accounts at the Cabinet Office before joining to Kyoto Sangyo University in April 2020. He also taught at Kyoto University as a specially appointed professor and at National Graduate Institute for Policy Studies as an associate professor. In 1999, Hirota received an MA in economics from Rutgers University. His primary research interests are health economics and regional economics.

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Part I
Socio-Life Scientific Approach to COVID-19

Chapter 1
SARS-CoV-2 Variants: Past, Present and Future

Sharon J. Peacock

Abstract (Editors' note) This is based on a presentation that Sharon Peacock gave in April 17, 2021, at First RIETI CGM IPJO Joint International Workshop on Socio-life Science: Public health and COVID-19 Outbreak, held online at Reseach Institute of Economy, Trade and Industry (RIETI) and hosted jointly by RIETI, Kyoto University and Institut Pasteur. The aim of the talk was to give a broad overview, and the references in the slides (and provided here) were to provide examples of the relevant literature rather than a comprehensive literature review. The talk was given before the WHO announced a naming scheme for variants using the Greek alphabet, and prior to Delta variant being defined as a Variant of Concern.

Keywords SARS-CoV-2 · Variants

1 Introduction: Overview of COG-UK

I want to thank the organizers of this meeting for their kind invitation. It is a great honour for me to be able to speak to you today.

Figure 1 shows the landing page of the COG-UK website. Please do have a look at the website if you are working in the field of SARS-CoV-2 genomics. Our website contains news, reports, blogs and a variety of other information. There are also links to numerous analytical tools and methods. The landing page shows that we have so far sequenced around 430,000 SARS-CoV-2 genomes in the UK. This is the single largest effort in the UK to date to sequence a single pathogen.

I want to talk today about variants past, present, and future. Before I do that, I want to talk briefly about COG-UK (Fig. 2). This began on April 1, 2020, making us just over a year old. This brought together the many pathogen genomics experts in the UK. It was only a matter of time before SARS-CoV-2 evolved in a way that would challenge us in terms of efficacy of therapeutics and vaccines, and we needed to be prepared.

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Fig. 1 COVID-19 Genomics UK Consortium website. *Source* Peacock (2021)

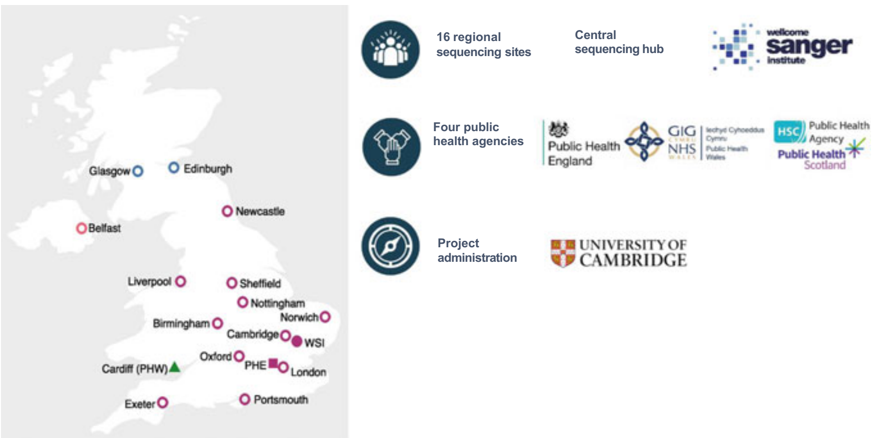


Fig. 2 COVID-19 GENOMICS UK (COG-UK) consortium. *Source* Peacock (2021)

With government funding and the support of the UK Government Chief Science Advisor Sir Patrick Vallance, we set up a project in April 2020 whereby we had a network of regional sequencing hubs, which were largely academic sites across the country as shown on the map (Fig. 2), together with the Wellcome Sanger Institute.

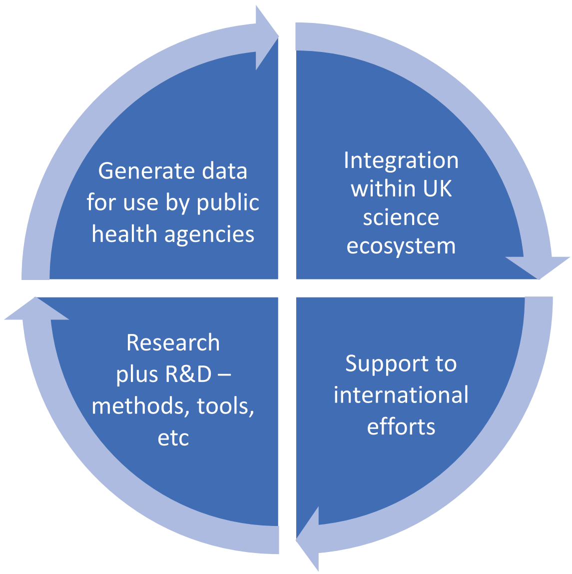
These are linked with the four public health agencies in England, Wales, Scotland, and Northern Ireland.

COG-UK has four main objectives (Fig. 3). First, we aim to generate data for use by public health agencies and public health interventions. Second, we develop tools and methods for sequencing and analysis, which are open access. We also make our genome data available in open access databases. Third, we support international efforts—we want to support international partners through collaboration and provision of expertise. Fourth, we aim to integrate our data within the wider UK science ecosystem.

Sequencing is supported by our sampling strategy (Fig. 4). Our maximum potential sequencing capacity is around 30,000 genomes a week. Half of our sequencing capability is used to sequence unbiased, random samples. We sequence samples from across the UK without selection criteria so that we can detect changes in the virus in all regions of the country. The remaining capacity is used on targeted public health sampling such as outbreaks and surge testing when, for example, we know there is a cluster of cases infected with a variant of concern, such as B.1.351, the variant of concern first detected in South Africa. We also provide sequencing to support the UK core national studies (for example, longitudinal surveillance studies) (Fig. 5).

This map of the UK (Fig. 6) shows the origin of SARS-CoV-2 positive samples that are sequenced by the regional sequencing hubs. Each NHS diagnostic testing laboratory that undertakes PCR testing for COVID-19 is connected to a specific regional hub. Each dot representing a testing lab is color-coded based on the sequencing hub that positive samples are then transferred to.

Fig. 3 COG-UK objectives. *Source* Peacock (2021)



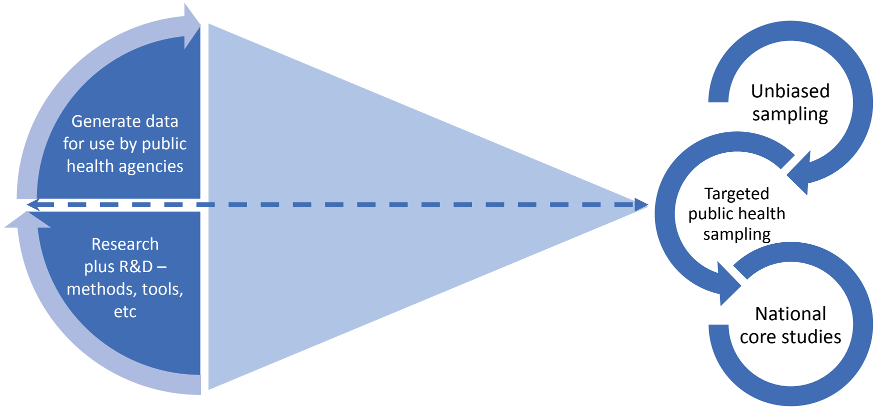


Fig. 4 COG-UK objectives and sampling. *Source* Peacock (2021)

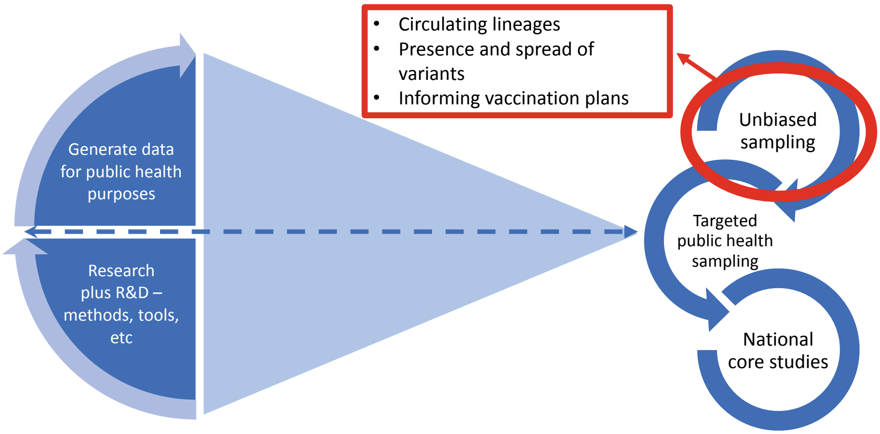


Fig. 5 COG-UK objectives and sampling. *Source* Peacock (2021)

The UK has an extensive SARS-CoV-2 community testing capability, which is conducted through a network of lighthouse laboratories (Fig. 7). PCR samples from these labs are sent to the Wellcome Sanger Institute for sequencing.

Coverage (number of samples sequenced versus the number positive) for the most recent week that we have complete data for is around 40%, and cumulatively over the entire pandemic is around 10% (Fig. 8).

Targeted sequencing is important to understand ongoing public health challenges. We sequence positive samples associated with people who are in quarantine, and from surge testing and outbreak investigations (Fig. 9).

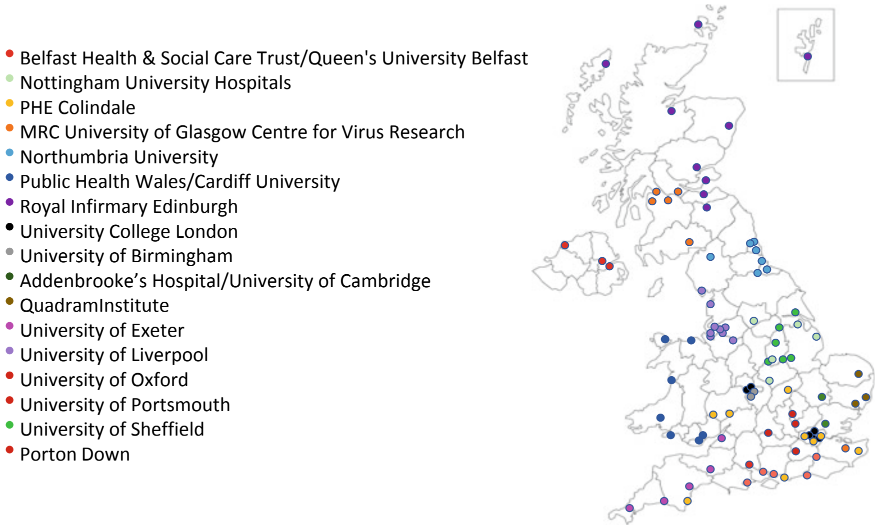


Fig. 6 Sequencing network: hospital laboratories and patients ("pillar 1"). *Source* Peacock (2021)

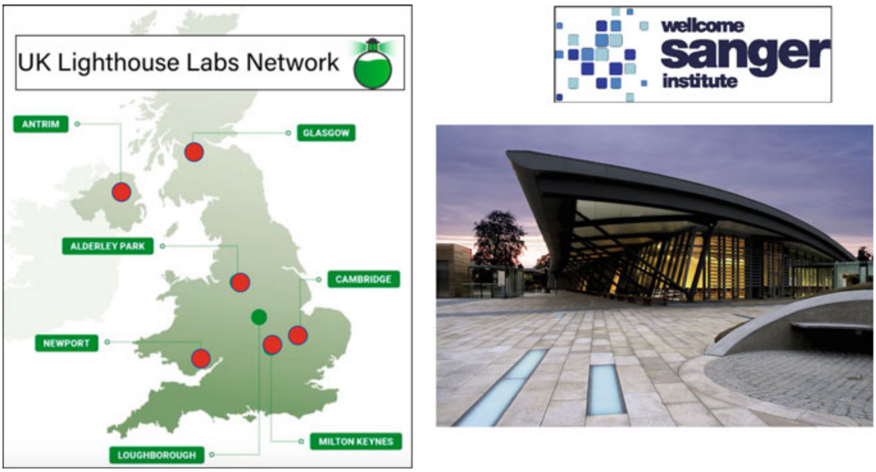


Fig. 7 Sequencing network: community testing ("pillar 2"). *Source* Peacock (2021)

2 Viral Variants: Context and Drivers

I would now like to talk about viral variants in terms of context and drivers of their emergence.

At the top of Fig. 10, you will see a schematic of the SARS-CoV-2 genome (Andersen et al. 2020), which has around 30,000 bases. The current focus of attention is predominantly the gene encoding the spike protein. The SARS-CoV-2 genome

	Overall coverage	
	Cumulative	Week
UK	400,068 (9.3%)	16,387 (42.3%)
Wales	38,509 (18.5%)	759 (60.8%)
Scotland	30,838 (14.4%)	2,360 (60.9%)
England	325,227 (8.6%)	13,224 (40.6%)
Northern Ireland	5,494 (4.7%)	44 (4.2%)

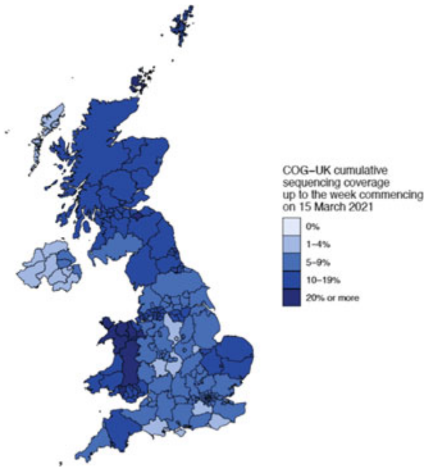


Fig. 8 Country coverage. *Source* Peacock (2021)

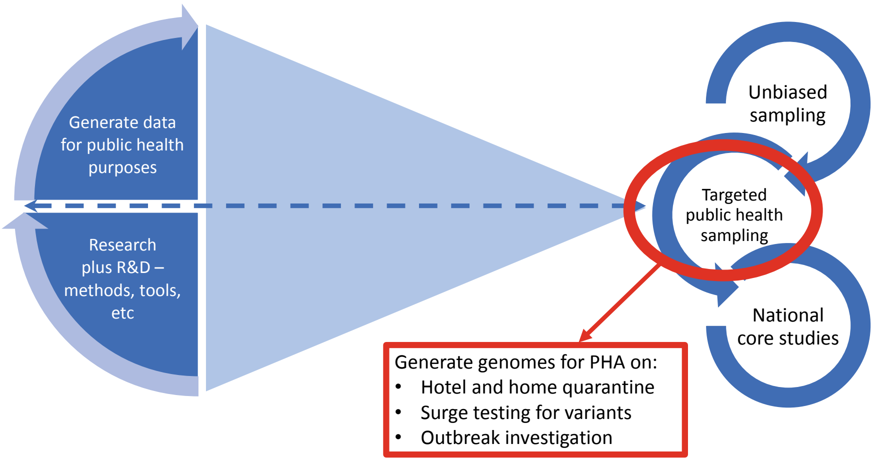


Fig. 9 COG-UK objectives and sampling. *Source* Peacock (2021)

encodes four structural proteins, but the spike protein is the major focus because this is the part of the virus against which antibodies (and vaccines) are largely targetted. The spike protein is involved in binding to the human ACE2 receptor and cell entry, and so is a critically important part of the virus for the infective process.

Mutations in the SARS-CoV-2 genome occur at a rate of around one or two per month and these are largely random in the genome. Many of these mutations have no effect on the virus and no change to the biology/phenotype. Some mutations will be disadvantageous to the virus and may not be observed at all or that virus may become extinct after a period. The mutations that we are most concerned about are

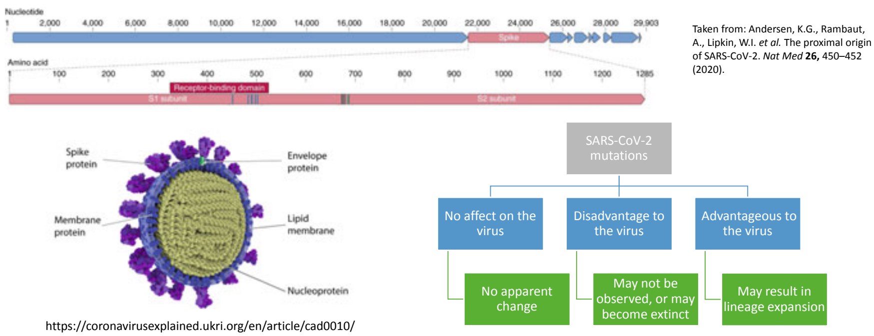


Fig. 10 SARS-CoV-2 genome and mutations. *Source* Peacock (2021)

those that are associated with a fitness advantage to the virus, which may lead to lineage expansion.

Here, I list the characteristics that could arise from mutations that are important for human health (Fig. 11). These fall into four categories. First, the virus may become more transmissible. Second, changes may lead to immune escape. That means that our vaccines or immunity acquired after COVID-19 infection may become less effective. Third, disease severity may increase (and it may decrease). Fourth, some genetic changes could impact diagnostic tests. A variant may have one or a combination of these depending on the changes that occur in the genome.

Turning to those environments that are permissive for the emergence and selection of mutations and variants of concern, I have listed four categories (Fig. 12). The first is sustained transmission in settings with high disease rates. If there is no disease, there is very little opportunity for the virus to mutate. With more than 120 million or

Fig. 11 SARS-CoV-2 variants: implications for human health. *Source* Peacock (2021)

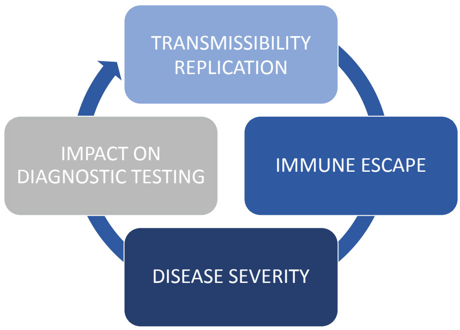


Fig. 12 Permissive environments for the selection of mutations and variants of concern. *Source* Peacock (2021)

- Sustained transmission in settings with high disease rates
- Transmission in populations with natural or induced immunity
- Prolonged infection in immunocompromised patients
- Human to animal passage

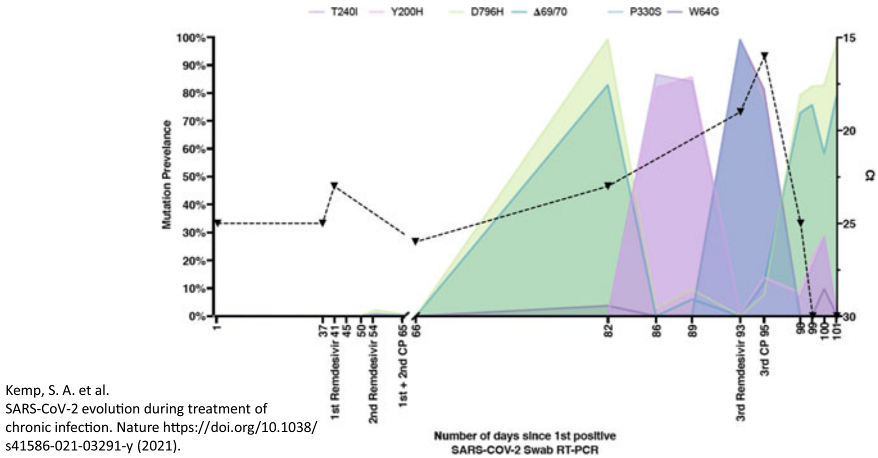


Fig. 13 SARS-CoV-2 evolution during treatment of chronic infection. *Source* Peacock (2021)

more cases known to have occurred worldwide there is plenty of opportunity for the virus to mutate. This also means that even though the rate of mutation of the virus is considered to be relatively low, this does not mean to say that the number of mutations will be low. The second permissive environment is when there is transmission in populations with natural or induced immunity, including partial immunity. Through selection of the fittest, variants may be selected that can find chinks in the armour of our immunity and cause infection (escape variants). In an immune population, these are likely to be selected from circulating viruses. The third category is the selection of mutations and variants during prolonged infection in immunocompromised patients. Fourth is the concern that passage of the virus between humans and animals can lead to evolutionary changes that could lead to important changes in biology for human infection and disease control.

Figure 13 shows a graph of SARS-CoV-2 viral evolution in a single patient during treatment of chronic infection (Kemp et al. 2021). The patient was a male individual who had a history of B-cell lymphoma and had been treated with chemotherapy in 2012. He presented to hospital with SARS-CoV-2 infection and had persistent infection over a prolonged period. The graph shows the results of ultra-deep sequencing of SARS-CoV-2 from the patients on 23 occasions over a period of 101 days. The frequency of specific mutations is shown on the left axis and the CT value from the diagnostic PCR test is shown on the right axis. The peaks in the graph show the most common mutations that emerged. In the first 65 days, there was very little change in the virus, including during two courses of Remdesivir. The patient then went on to receive convalescent plasma. Following the first two doses, a range of mutations emerged, with some variants becoming dominant at specific time points. Mutation D796H and the deletion △69/70 together led to a modest reduction in sensitivity to convalescent plasma antibodies. This is like a training ground for viral evolution.

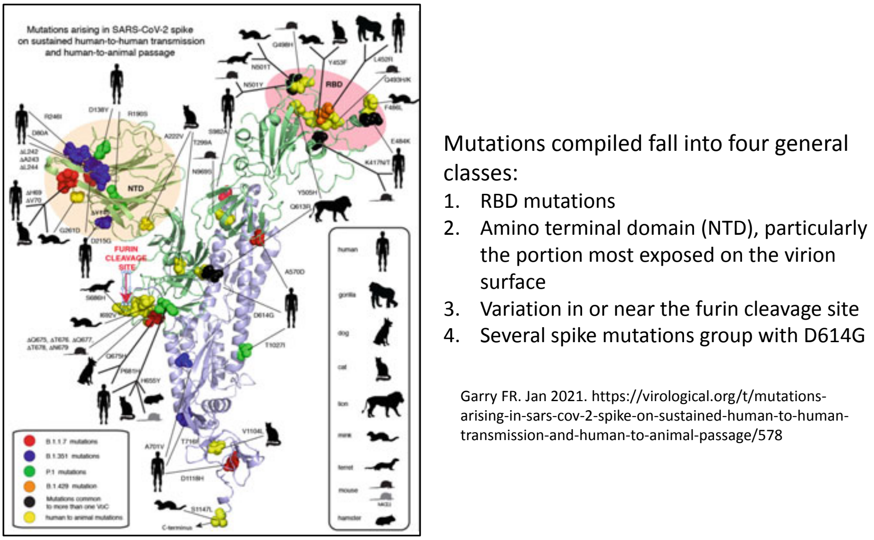


Fig. 14 Compilation of mutations arising in spike on sustained transmission. *Source* Peacock (2021)

It has been hypothesized that some of the variants of concern may have arisen in patients who are chronically infected and who cannot clear the virus.

I have already referred to the importance of human to animal passage of the virus. Figure 14 shows work by Robert F. Garry published in January 2021 (Garry et al. 2021) The figure shows a compilation of mutations arising in the spike protein on sustained human-to-human transmission and human-to-animal passage. Mutations are grouped into four different classes. The first is in the receptor binding domain, shown at the top of the figure. Some mutations, for example, the N501Y substitution present in the B.1.1.7 lineage, first detected in the UK and associated with greater transmission, have emerged during transmission between humans, but have also emerged in animals. The second is mutations in the N-terminal domain of the spike protein, particularly in the portion most exposed on the surface of the virus. Third is mutations in or near the furin cleavage site, and fourth is mutations around the region of the D614 gene mutation, which emerged early in the pandemic and was associated with a range of biological changes in the virus.

3 Sars-Cov-2 Variants: Past

Next, I am going to talk about some mutations and variants observed in the past, starting with the D614G substitution. This was not present in the virus that first emerged but appeared around March 2020.

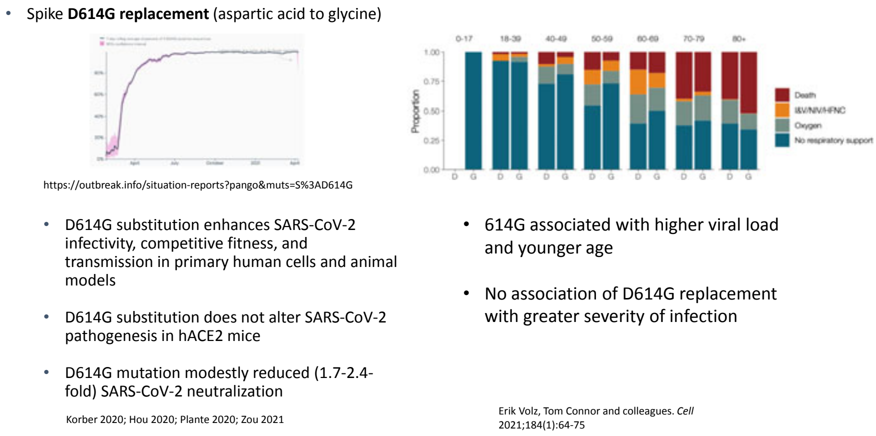


Fig. 15 D614G substitution: an early lesson in evolving biology. *Source* Peacock (2021)

The graph (top left) (Fig. 15) shows the emergence and D614G replacement over time on a global scale. This substitution enhances infectivity, competitive fitness, and transmission in primary human cells and animal models, results in a modest reduction in SARS-CoV-2 neutralization but does not alter pathogenicity in mice (Hou 2020; Korber 2020; Plante 2020; Zhou 2020).The latter finding is replicated in humans (Volz et al. 2021).The graph (top right) shows outcomes from infection in people admitted to hospital with SARS-CoV-2 who were either infected with the D or the G version, shown in age groups. There was no difference between D and G for patients who required oxygen or ventilation, or who died. But the mutation was associated with a higher viral load and a younger age of infection when the variant first emerged. What this shows us is that a single change in the virus can lead to a fundamental change in the biology of the virus. However, it has taken many months to undertake the experimental work. While we wish to understand the impact of viral genetic changes very rapidly, it does take time to perform the necessary experiments.

4 Sars-Cov-2 Variants: Present

I am going to now talk about variants, present.

Shown here (Fig. 16) is the latest chart from Public Health England on the gov.uk website in the UK, listing variants being tracked there. One further variant was added in the last day or so, first detected in India but not shown here. I will focus on four variants of concern in the UK, three of which are variants of concern listed by the World Health Organization. The first was initially detected in England—B.1.1.7. The second is the variant first detected in South Africa—B.1.351. The third is P.1 first detected in Japan and appeared to have emerged in Brazil. The fourth is B.1.1.7 with the addition of E484K.

Variant	Other names by which this variant may be known*	Lineage	Country in which first detected	Genomically confirmed cases**	Genomically probable cases**	Total genomically confirmed and probable cases^	New cases since last update (data up to 7 April)
VOC-20DEC-01	VOC-202012/01	B.1.1.7	England, UK	N/A	N/A	193,315	+20,273
VOC-20DEC-02	VOC-202012/02	501Y.V2 B.1.351	South Africa	533	11	544	+75
VUI-21JAN-01	VUI-202101/01	P.2	Brazil	59	0	59	0
VOC-21JAN-02	VOC-202101/02	P.1	Japan ex Manaus, Brazil	35	1	36	+4
VUI-21FEB-01	VUI-202102/01	A.23.1 with E484K	England, UK	79	0	79	+1
VOC-21FEB-02	VOC-202102/02	B.1.1.7 with E484K	England, UK	43	0	43	0
VUI-21FEB-03	VUI-202102/03	B.1.525 (previously designated UK1188)	England, UK	328	6	334	+37
VUI-21FEB-04	VUI-202102/04	B1.1.318	TBC	99	5	104	+25
VUI-21MAR-01	VUI-202103/01	B1.324.1 with E484K	TBC	2	0	2	0
VUI-21MAR-02	N/A	P.3	TBC	5	0	5	0

Fig. 16 Variants as defined by PHE April 7, 2021. *Source* Peacock (2021)

Figure 17 shows a national overview of lineages in the UK based on sequence data generated by the Wellcome Sanger Institute (community surveillance) between September 2020 and March 2021. The top image shows incidence of major lineages over time, and the bottom image shows the proportion. Our prevalent lineage early in this period (B.1.177) was first detected in Spain and appeared to spread across Europe as a result of travel, rather than any biological characteristic of the virus. This was replaced over time by B.1.1.7. Around 98% of all infection in our country currently is caused by B.1.1.7.

B.1.1.7 was first detected in the south of England, and it has since been reported in at least 114 countries (Fig. 18) [for selected studies on aspects of B.1.1.7, see Collier (2021), Garcia-Beltran (2021), Lumley (2021), NERVTAG (2021), Nunez (2021), Planas (2021), Wang (2021)].This variant was striking when it first emerged, because

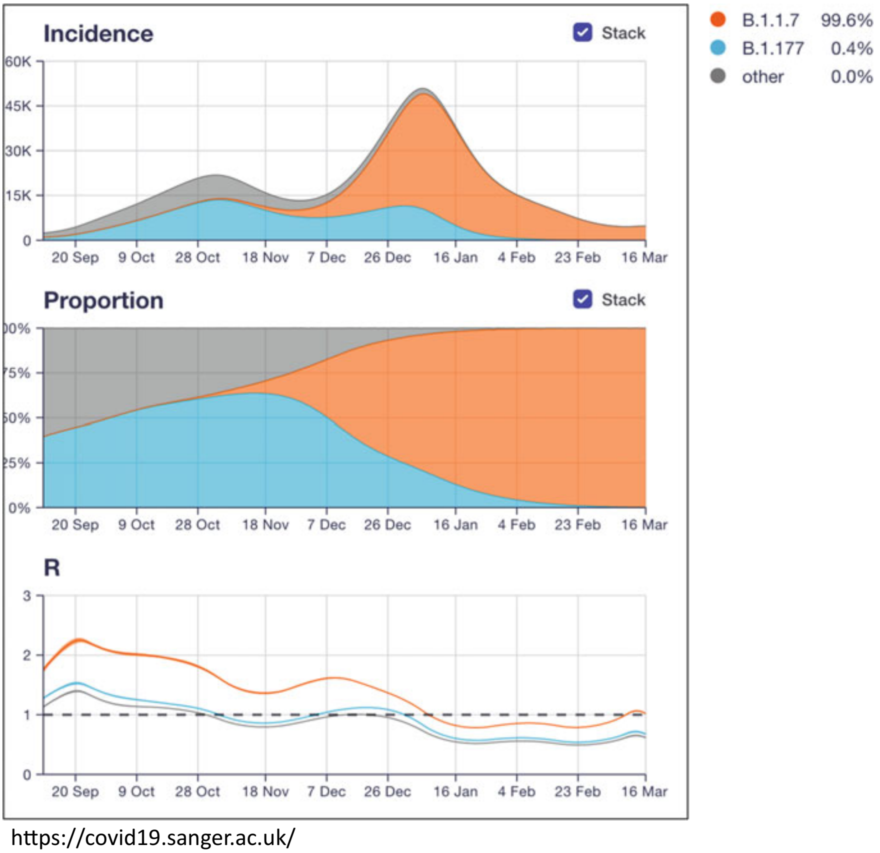


Fig. 17 National overview, England. *Source* Peacock (2021)

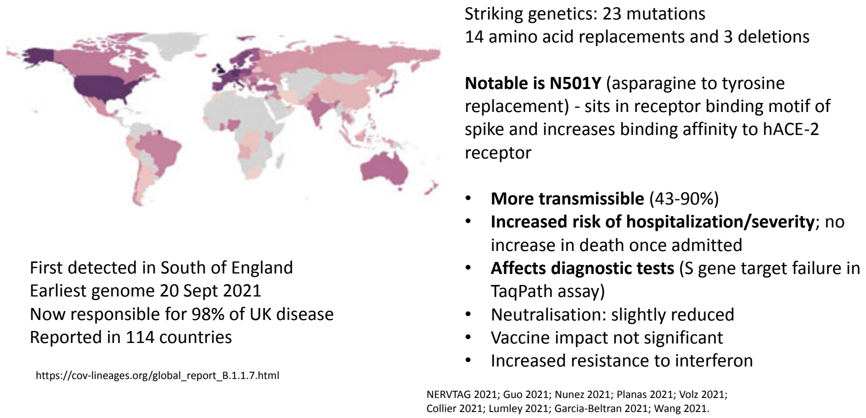


Fig. 18 Lineage B.1.1.7 (UK). *Source* Peacock (2021)

of the number or mutations it carried (n = 23). But the most notable substitution is N501Y, which sits in the receptor binding motif of the spike and increases binding affinity to the human ACE2 receptor. This variant is more transmissible (range, 43–90%). There are a large number of studies on virulence of this variant, which appears to cause more severe disease and increased risk of hospitalization, but people admitted to hospital do not have an increased risk of death. This variant also affects specific diagnostic tests, with S-gene target failure. This does not lead to test failure and has been useful as a surrogate for B.1.1.7, which is an accurate marker when the prevalence of B.1.1.7 is high. Antibody neutralization is slightly reduced, but vaccine impact is not significant. A recent study suggests that this variant may interfere with the innate immune response, with evidence for increased resistance to interferon (Guo et al. 2021).

Figure 19 shows the antigenic variation that is occurring in B.1.1.7 in the UK over time. It demonstrates that there is increasing genetic change in B.1.1.7, including numerous independent occasions when E484K has emerged. You can find this image (which is regularly updated) in the open access tool, COG-UK Mutation Explorer.

B.1.351 was first detected in South Africa (Fig. 20). The earliest genome was detected on October 8, 2020, and at least 69 countries have detected at least one B.1.351 sequence [for selected studies on aspects of B.1.351, see Cele (2021), Dejnirattisai (2021), Garcia-Beltran (2021), Moyo-Gwete (2021), Madhi (2021), Liu (2021), Wu (2021)]. There are spike gene substitutions with likely functional significance (K417N, E484K and N501Y). The variant is thought to be more transmissible. There was a reported 20% increased risk of in hospital mortality during the second wave in South Africa, noting that a high burden of cases can place pressure on hospitals. An important concern is that neutralization is substantially decreased in experimental work, using sera from people taken after infection. Furthermore, there

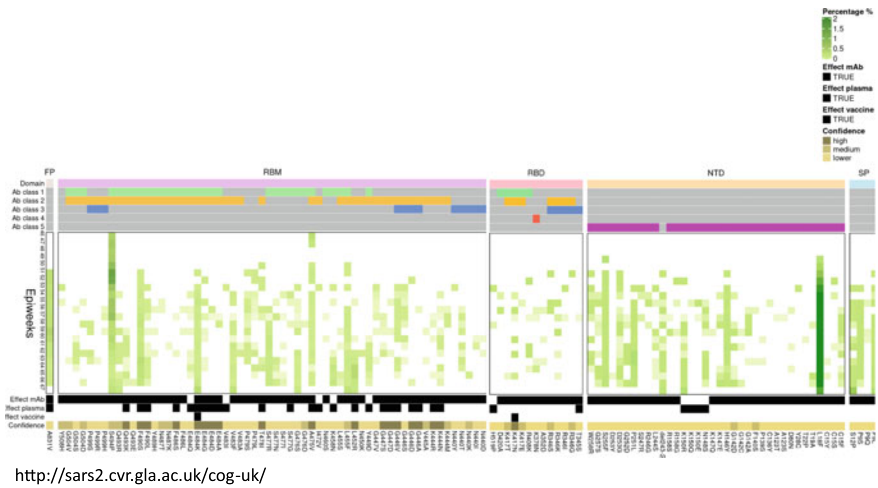


Fig. 19 B.1.1.7 antigenic variation over time. *Source* Peacock (2021)

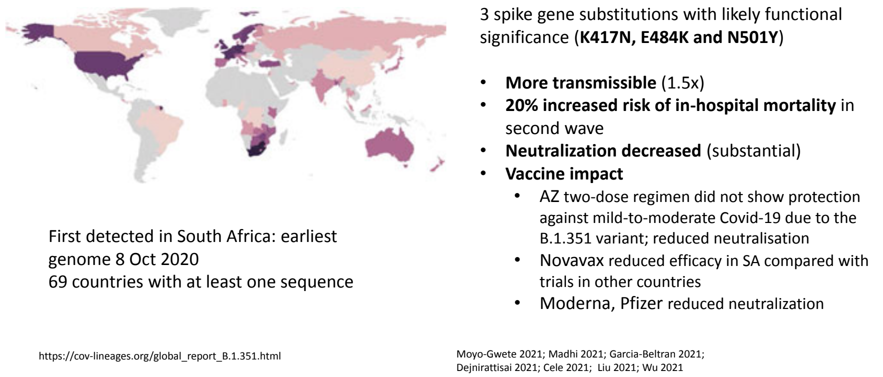


Fig. 20 Lineage B.1.351 (South Africa). *Source* Peacock (2021)

appears to be an effect on vaccine efficacy. In a study of the AZ vaccine, a two-dose regimen did not show protection against mild to moderate COVID-19 due to the B.1.351 variant. But this was a relatively small study in a young population, and we cannot exclude that this vaccine would protect people from severe disease and death. The results are, therefore, inconclusive.

The P.1 lineage was first detected in Brazil and was also detected in Japan in people who were entering the country (Fig. 21). The earliest genome dates back to December 4, 2020, and 35 countries have detected at least one P.1 sequence to date [for selected studies on P.1, see Coutinho (2021), Dejnirattisai (2021), Faria (2021), Garcia-Beltran (2021), Lui (2021), Wu (2021)]. This variant has spike protein substitutions with likely functional significance (K417N, E484K and N501Y). You will observe the similarity in mutations in spike with B.1.351, and the phenotype of the variant is proving to be similar, including increased transmissibility. Whether P.1 is associated with altered disease severity is currently unclear. A moderate reduction

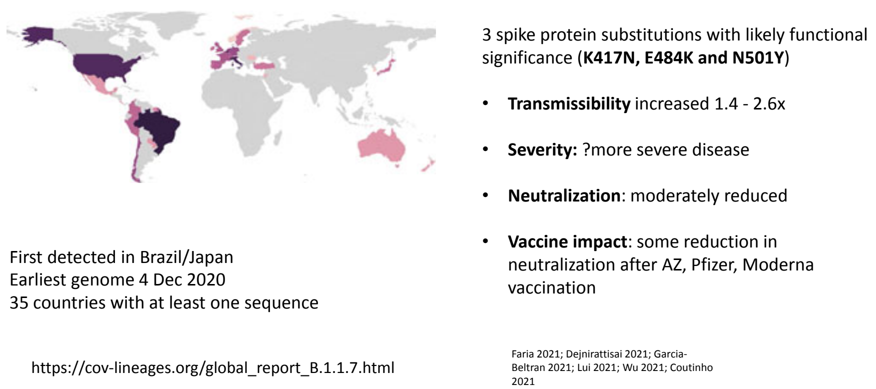


Fig. 21 Lineage P.1 (Brazil). *Source* Peacock (2021)

in neutralization is observed, including some reduction in neutralization using sera from people following vaccination with one of several vaccines.

A study by Garcia-Beltran et al. (2021) looked at comparative neutralization of a range of variants using serology samples from 99 individuals who either had one or two doses of the Pfizer or Moderna vaccine (Fig. 22). This overcomes the problems of comparing neutralization results between different labs. Across the ten variants tested, neutralization was strongest for wild type, and weakest for the B.1.351—which was equivalent to neutralization for other coronaviruses, including SARS-CoV.

From the same work (Garcia-Beltran et al. 2021), Fig. 23 shows the actual fold decrease in neutralization (Fig. 23). There is a marked decrease in pseudovirus neutralization relative to the wild type for three variants of B.1.351, for both Pfizer and Moderna vaccine sera.

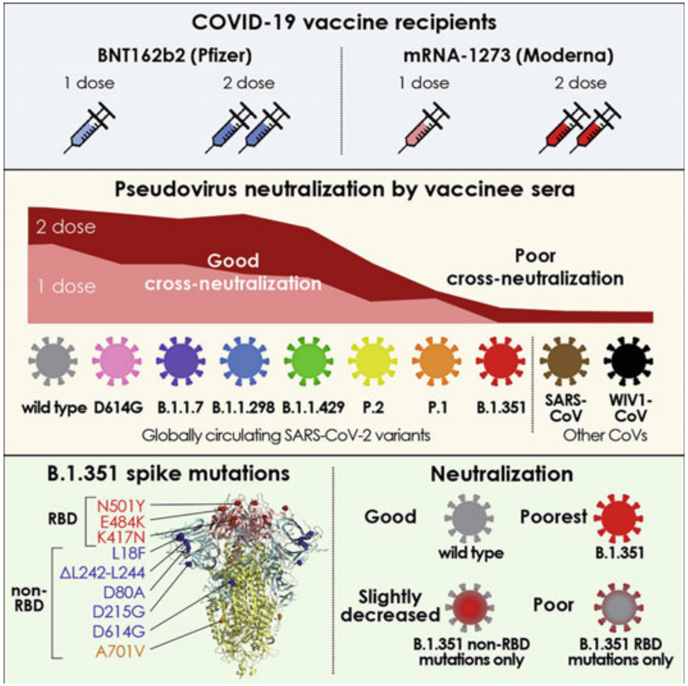
5 Sars-Cov-2 Variants: Future

So, what does the future hold?

Many changes that have occurred in the SARS-CoV-2 genome in different lineages around the world are in comparable positions in the genome (Fig. 24). This is consistent with convergent evolution, where variants are selected based on phenotypes that allow the virus to persist and spread in populations that are becoming increasingly immune. In this figure, you can see the root of the viral phylogeny at the start of the pandemic, after which there was a division into the two major lineages, A and B. Lineages have arisen over time, mostly from B.1, with several variants having the E484K mutation and/or the N501Y mutation.

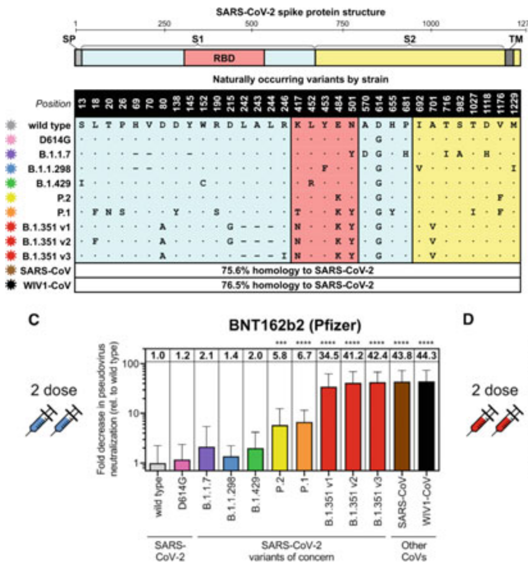
There are ongoing discussions in COG-UK and elsewhere about the importance of shifting our thinking from single variants to constellations of mutations (Fig. 25). The table shows the key genetic changes in a number of variants. This reflects the early beginnings of cataloging amino acid substitutions that are particularly important in terms of their biology. We are observing a shifting and dynamic fitness landspace over time, as SARS-CoV-2 evolves in human populations as they develop increasing immunity.

Can we predict the future in terms of variants, and what can we expect? I compare this to looking into a crystal ball because it is very difficult to accurately predict what might happen to the genome in the future (Fig. 26). I think it likely that there will be further emergence of variants of concern, which will be driven by high transmission in populations with partial immunity, and may be associated with chronically infected people and human to animal passage. I would expect there to be increasing complexity in describing, tracking, and understanding variants over time. There is an optimistic point that by sequencing the viruses as they change, we can provide this information to vaccine developers. And even now, vaccine developers are developing vaccines against the first variant of concern (B.1.351), and studies are looking at the effect of a third booster dose on immunity. The genetic changes we have observed to date are



Garcia-Beltran et al., Multiple SARS-CoV-2 variants escape neutralization by vaccine-induced humoral im- munity, Cell (2021), https://doi.org/10.1016/j.cell.2021.03.013

Fig. 22 Comparative neutralization of variants. *Source* Peacock (2021)



Garcia-Beltran et al., Multiple SARS-CoV-2 variants escape neutralization by vaccine-induced humoral im- munity, Cell (2021), https://doi.org/10.1016/j.cell.2021.03.013

Fig. 23 Comparative neutralization of variants. *Source* Peacock (2021)

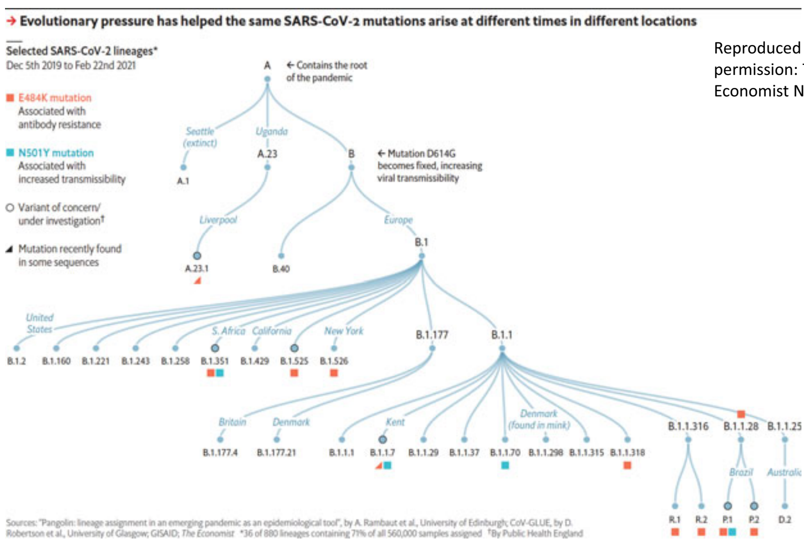


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Fig. 24 Convergent evolution. *Source* Peacock (2021)

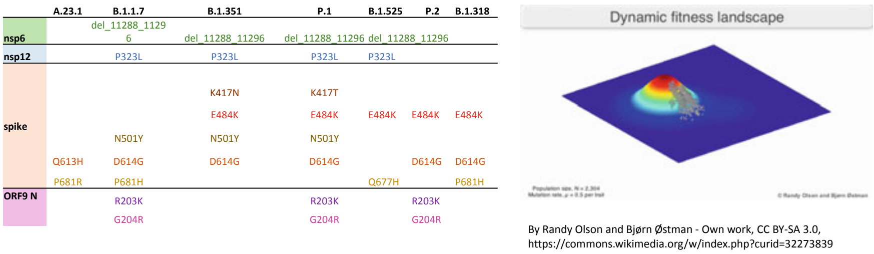

Fig. 25 Convergence of mutations: "constellations". *Source* Peacock (2021)

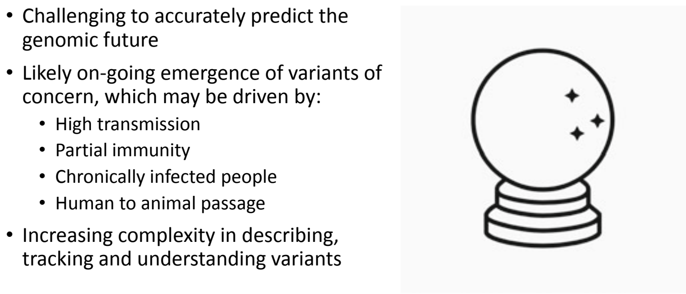

Fig. 26 Looking to the future: what we could expect. *Source* Peacock (2021)

not associated with a virus that is highly resistant to current vaccines. In the future we will be using sequencing data to modify vaccine strategies over time, as this proves necessary.

What actions will be needed in the future? Cases of COVID-19 cause by variants of concern can still be prevented by the usual precautions—hands (washing), face (masks), and space (social distance and outdoors) (Fig. 27). This will be effective against variants and is a key plank in our control of the virus. We also need to focus on global vaccine rollout. It is not sufficient to vaccinate in particular countries and then hope for the best. We need to vaccinate the world. In places where disease rates are high, this is also likely to be where further variants of concern will emerge. We need to protect everybody by vaccinating everybody.

A sure way to protect populations is through travel restrictions, although different countries have reached different decisions about travel restriction policy. But quarantine, testing and tracing are key elements of public health control together with ongoing vaccines and if required, vaccine modification. National surveillance is highly effective in numerous countries, but a global network of sequencing capabilities and data-sharing platforms are not currently in place. We need this to understand what variants are circulating where, to ensure that vaccines in use will be effective. We need a network of sequencing capabilities with global information sharing, together with effective pipelines for genotype to phenotype evaluation, immunology, and other experimental systems.

INTERVENTIONS (all cases, not limited to variants)

- Hands, face, space
- Global vaccine roll-out
- Travel restrictions
- Quarantine, isolation, testing, tracing
- Ongoing vaccine modification and boosters as necessary

SURVEILLANCE

- National and international surveillance
- Global network of sequencing capabilities and data platforms
- Global information sharing

RESEARCH

- Pipelines for genotype to phenotype immunology, other experimental systems

Fig. 27 Looking to the future: what actions will be needed. *Source* Peacock (2021)

This (Fig. 28) is the most important slide of my talk. The COG-UK consortium contains around 500 people, all of whom have contributed to the work that I have talked about today, and I am deeply indebted and grateful to all of them.

I would like to thank you for listening. Thank you.

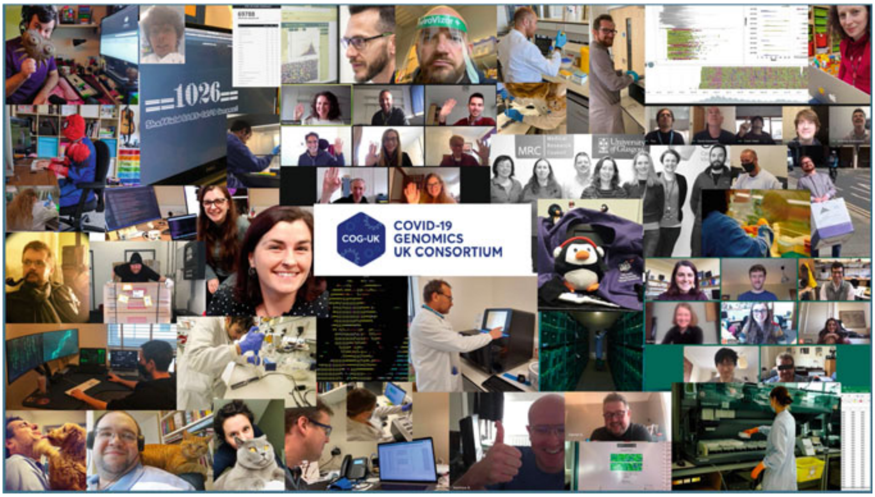

Fig. 28 Representation of the COG UK COVID 19 Genomics UK Consortium 'SARS-CoV-2 variants: past, present and future' presentation. *Source* Peacock (2021)

References

Andersen K, Rambaut A, Lipkin WI et al (2020) The proximal origin of SARS-CoV-2. Nat Med 26:450–452

Cele S et al (2021) Escape of SARS-CoV-2 501Y.V2 from neutralization by convalescent plasma. Nature 593:142–146

COG-UK Mutation Explorer: http://sars2.cvr.gla.ac.uk/cog-uk/

Collier DA et al (2021) Sensitivity of SARS-CoV-2 B.1.1.7 to mRNA vaccine-elicited antibodies. Nature 593:136–141

Coutinho RM et al (2021) Model-based estimation of transmissibility and reinfection of SARS-CoV-2 P.1 variant, medRxiv, preprint. https://doi.org/10.1101/2021.03.03.21252706

Dejnirattisai W et al (2021) Antibody evasion by the P.1 strain of SARS-CoV-2. Cell 184–11:2939–2954

Economist (2021) The same covid-19 mutations are appearing in different places -Convergent evolution may make travel restrictions redundant. The Economist, February 27. www.economist.com/graphic-detail/2021/02/27/the-same-covid-19-mutations-are-appearing-in-different-places

Faria NR et al (2021) Genomics and epidemiology of the P.1 SARS-CoV-2 lineage in Manaus, SBrazil. Science 372:815–821

Garcia-Beltran et al (2021) Multiple SARS-CoV-2 variants escape neutralization by vaccine-induced humoral immunity. Cell 184–9:2372–2383. https://doi.org/10.1016/j.cell.2021.03.013

Garry FR (2021) Mutations arising in SARS-CoV-2 spike on sustained human-to-human transmission and human-to-animal passage. https://virological.org/t/mutations-arising-in-sars-cov-2-spike-on-sustained-human-to-human-transmission-and-human-to-animal-passage/578

Global Report Investigating Novel Coronavirus Haplotypes (GRINCH). https://cov-lineages.org/global_report.html

Guo et al (2021) Interferon resistance of emerging SARS-CoV-2 variants. www.biorxiv.org/content/10.1101/2021.03.20.436257v1.full.pdf

Hou YJ (2020) SARS-CoV-2 D614G variant exhibits efficient replication ex vivo. Science 370:1464–1468

Kemp SA et al (2021) SARS-CoV-2 evolution during treatment of chronic infection. Nature 592:277–282

Korber B et al (2020) Tracking changes in SARS-CoV-2 spike: evidence that D614G increases infectivity of the COVID-19 virus. Cell 182–4:812–827

Liu Y et al (2021) Neutralizing activity of BNT162b2-Elicited Serum. N Engl J Med 384:1466–1468

Lumley SF et al (2021) Antibody status and incidence of SARS-CoV-2 infection in health care workers. N Engl J Med 384:533–540

Madhi SA et al (2021) Efficacy of the ChAdOx1 nCoV-19 Covid-19 vaccine against the B.1.351 variant. N Engl J Med 384:1885–1898

Moyo-Gwete T (2021) Cross-reactive neutralizing antibody responses elicited by SARS-CoV-2 501Y.V2 (B.1.351). N Engl J Med. https://doi.org/10.1056/NEJMc2104192

NERVTAG (2021) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/961037/NERVTAG_note_on_B.1.1.7_severity_for_SAGE_77__1_.pdf

Nunez IA et al (2021) SARS-CoV-2 B.1.1.7 infection of Syrian hamster does not cause more severe disease and is protected by naturally acquired immunity. bioRxiv, https://doi.org/10.1101/2021.04.02.438186. Preprint

Peacock S (2021) SARS-CoV-2 variants: past, present and future. Lecture presented at the RIETI-CGM-IPJO Joint International Workshop on Socio-life Science: Public health and COVID-19 outbreak, RIETI, Tokyo, Japan, 17 April 2021

Planas D et al (2021) Sensitivity of infectious SARS-CoV-2 B.1.1.7 and B.1.351 variants to neutralizing antibodies. Nat Med 27:917–924

Plante JA et al (2020) Spike mutation D614G alters SARS-CoV-2 fitness. Nature 592:116–121

Volz E et al (2021) Evaluating the effects of SARS-CoV-2 spike mutation D614G on transmissibility and pathogenicity. Cell 184–1:64–75

Wang et al (2021(Susceptibility of circulating SARS-CoV-2 variants to neutralization. N Engl J Med. https://doi.org/10.1056/NEJMc2103022
Wu K et al (2021) mRNA-1273 vaccine induces neutralizing antibodies against spike mutants from global SARS-CoV-2 variants. bioRxiv, https://doi.org/10.1101/2021.01.25.427948. Preprint
Zhou B et al (2020) SARS-CoV-2 spike D614G change enhances replication and transmission. Nature 592:122–127

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Chapter 2
COVID-19 Pandemic and Behavioural Change: The Cases of Florida and Ohio

Makoto Yano

Abstract This study investigates the influences of COVID-19 spread at an early stage of the pandemic by focusing the cases in Florida and Ohio. Evidence is provided indicating that if the messages delivered by the national leadership and the local leadership are unified and coordinated with each other (as in Florida), they have a significant impact on the public's behavioural change or its self-protection effort. Moreover, social learning appears to contribute to effecitve self-protection efforts of the public. These effects are not observed in a state in which mixed messages are sent by the national and local government (Ohio).

Keywords COVID-19 outbreak · Political factors · Social learning

1 Introduction

By now, it has become clear that behavioural change—starting to wear a mask and keeping a social distance—is one of the most important keys to fight the COVID-19 outbreak. As the outbreak enlarges, we see that people's readiness for such behavioural change depends on various socio-life scientific factors: Epidemiological, political scientific, economic, sociological, behavioural, among others. The present study investigates the roles of these factors by focusing on a very early stage of the pandemic (mid-April, 2020) in the US state of Florida; this focus is set to capture the pure effects of those factors without unnecessary noises. Data on 67 counties is used. Our results support the existence of a natural epidemiological factor in the

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way the disease spread and the importance of political leadership in containing the pandemic. Some evidence is found that suggests the positive role of social learning in guiding people to make behavioural change towards self-protection.

There are several reasons why we focus on Florida. One is that Florida is a big peninsula mostly surrounded by the sea; only the northern border is connected to other states. Moreover, the population is spread over the state with population centers at Miami (population, 5,502,400) on the southeast coast of the peninsula, Tampa (2,441,900) on the middle west coast, and Orlando (1,510,600) in the center. These geographical features are desirable to detect the natural factors that might be at work in the spread of the virus.

Another reason is that Florida offers a good proxy representing the role of political leadership. The more transparent information is, the better the decision. Despite this, however, President Trump downplayed the danger of, and overstated the government's capability of handling, the outbreak of COVID-19 through the middle of March 2020.[1] The governor of Florida, Ron DeSantis, strongly supported the president's view. If people were more readily to believe the overly-optimistic messages from these leaders, they would tend to underprepare against the outbreak, thereby increasing the likelihood of catching the virus and spreading it to others. By investigating this scenario, we capture the role of political leadership.

This study tries to capture the social learning factor of people by the population density and number of cities of a particular region.[2] By mid-April 2020, it was clear that the instances of COVID-19 were worse in more populated urban regions on the northeast coast of the US, including New York, New Jersey, and Connecticut. If people learned from those experiences, those who lived in an urban region with a higher population density would be more careful and more readily change their behaviour to protect themselves against the virus. If so, the pandemic should spread less in a more populated urban region, thereby evidencing the presence of a social learning factor towards self-protection.

Our results show that the more core supporters of President Trump in a region, the larger number per capita of COVID-19 cases in Florida, which suggests the importance of political messages that a leader delivers in the fight against the pandemic. The more populated a region is, the smaller number per capita of COVID-19 cases. This effect is clearer if county population is adjusted by an urbanization factor of county. Except for the seven most populated counties, the more urban a county is, the smaller the number per capita of COVID-19 cases. For the seven most populated counties, the more urban a region is, the larger the number per capita. These results suggest that social learning towards self-protection takes place in more populated and more urban areas. However, if a county has too large a population, the self-protection effort is not enough effectively to fight against the virus.

Finally, the number of cases accelerates more quickly with the population of a region. This is consistent with the nature of virus transmission.

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[1] For example, see a *Washington Post* article by Blake (2020), which timelines Trump's early remarks on the outbreak.

[2] Sato et al. (2020).

These results are likely to be special features of Florida, which is relatively isolated from other populated regions. To confirm this, I conduct similar tests for the state of Ohio, which has similar political features, and find that no relationship exists between the number per capita of COVID-19 cases and various potential determinants.

2 Results

We capture the effect of local and national politics by the behaviour of core Trump supporters, which we represent by the ratio between the number of votes for the Republican Trump-supporting governor in the 2018 election and that for the president in the 2016 election, or

$$R = \frac{\#Votes\ for\ the\ Republican\ candidata\ in\ the\ 2018\ Gubernatorial\ election}{\#Votes\ for\ President\ Trump\ in\ the\ 2016\ election} \tag{1}$$

This choice of a proxy can be explained as follows: Florida is well known as a swing state, in which Republican and Democratic candidates have divided the total votes almost evenly between them in many past elections. In 2016, people voted for President Trump rather decisively. In 2018, Florida elected a new governor, Governor DeSantis, who has been widely regarded as a disciple of President Trump.[3] He has followed closely the policy taken by Trump. In 2018, as is well known, the president significantly lost popularity due to many scandals; the Republicans lost large numbers of seats nationwide in the 2018 election. From these facts, we may assume that the voters for Governor DeSantis in 2018 election were likely to be strong supporters for President Trump; in other words, the number of votes for Governor DeSantis in 2018 should closely be correlated to that of votes for President Trump in the 2016 election. minus the number of voters who decided no longer to support the president in 2018 election. For this reason, we assume that the ratio in a county between the number of votes for Governor DeSantis and that for President Trump captures the relative side of core Trump supporters in that county, which we call the leader index. Over the Florida counties, the index is distributed between 0.73 and 0.98.

This study conduct OLS (ordinary least squares) estimations to test a number of models that may explain the number per capita of COVID-19 cases by different explanatory variables. In those explanatory variables, the leader index may suffer from the endogeneity problem. In an election, people tend to vote for the candidate with whom they share personal philosophy; it is natural that the same personal philosophy influences how a person acts against the pandemic. As a result, the number of coronavirus cases and the governor/president ratio can be endogenously determined.

[3] In his *Guardian* article, Luscombe (2020) introduces the governor as a self-confessed Trump disciple (and often referred to as a "mini-Trump"). Also see Nazaryan (2020).

To deal with this problem, the present study conducts instrumental variable estimations after deciding the best fit model specification by OLS. As the instrumental variable, we adopt the county property tax, which may be positively correlated to the leader index. Because the county property tax is pre-determined way before the current COVID-19 outbreak, it is impossible that the number per capita of COVID-19 cases influences the county property tax. Moreover, it is highly unlikely that there is a direct channel through which the property tax influences the number per capita of COVID-19 cases. For these reasons, the property tax rate can be a good candidate for an instrument for the core Trump supporter index to explain the number per capita of COVID-19 cases.

Our findings may be summarized as follows.

Observation 1 In Florida, where the local leader followed the national leader by downplaying the danger of the virus at an early stage of the outbreak:

(1) the spread of the coronavirus accelerates with population,
(2) the larger the number of core Trump voters, the worse the spread of the virus,
(3) except for the seven most populated counties, the coronavirus cases per capita decrease with urbanization, and
(4) many economic factors have little effects on the spread of the virus.

It is highly likely that these results reflect unique features of Florida. To double check this possibility, we examine the cases in Ohio, which shares several crucial political characteristics. None of the above results are observed in Ohio data.

3 Literature

There are a number of studies that, like this study, focus on the early development of the pandemic. Here, I will explain only those studies; this study contributes to the literature that is concerned with political factors as a determinant of the outbreak. Bursztyn et al. (2020) investigate the effect of misinformation on the spread of a pandemic. They focus on two Fox News shows and demonstrate that greater viewership of the more pro-Trump show (Hannity) is associated with more COVID-19 cases and deaths in the early stages of the pandemic. Both this and their studies are based on Johns Hopkins data.

The rest of the literature that is concerned with the effectiveness of social distancing. Ajzenman et al. (2020) investigate the effect on social distancing of the Brazilian president's dismissal of the coronavirus risk. They show that his dismissal reduced social distancing more in pro-government localities, captured by geo-localized mobile phone data. Adolph et al. (2020) show that Republican governors and governors from states with more Trump supporters were slower to adopt social distancing policies. Allcott et al. (2020) report significant gaps between Republicans and Democrats in beliefs about personal risk, which may influence the future path of the pandemic. Barrios and Hockberg (2020) show that as Trump vote share rises, individuals search less for information on the virus and unemployment benefits and reduce less both their daily distance traveled and their visits to non-essential businesses. Anderson (2020) shows that mandatory measures on social distancing may have been effective at reducing the frequency of visits to locations outside of one's home. Brzezinski et al. (2020) show that individuals skeptical about the human causes of climate change are less likely to comply with social distancing regardless of their political views.

More broadly, this study is related to several studies that treat the epidemiology of the coronavirus pandemic from the social scientific viewpoint. By using internet data, Fetzer et al. (2020) document a rapid surge in economic anxieties after the arrival of the coronavirus in the US and substantial heterogeneity in participants' beliefs about mortality from and the contagiousness of the virus. Using county data on population movement derived from cell phone location data, Wright et al. (2020) build a theoretical model that shows that poverty and negative economic shocks from the US trade war will reduce compliance with social distancing.

There is a large volume of empirical studies that capture the effect of misinformation by media. For studies in that literature, see Bursztyn et al. (2020).

4 Data

We use only publicly available data. The data source for coronavirus cases is from the Johns Hopkins University Coronavirus Resource Center at https://coronavirus.jhu.edu/us-map/, which is the same as Bursztyn et al. (2020). Every day, this site refreshes, and updates, the numbers of cases and deaths in each US county. Our estimation is based on April 15, 2020, data for Florida and April 20, 2020, data for Ohio.

In addition to the leader index, R, the main explanatory variables include population, area and the number of cities, which are regarded as exogenous variables in our estimation equations. Many other explanatory variables are included as control and instrumental variables. They are: urban and rural population density, water area, per capital income, education, wage, median home value, average property tax, poverty rate, and the number of hospitals. We will come back to the choice of instrumental variables in Sect. 4.4.

In place of descriptive statistics, we present the plots of vectors of main variables; the left-hand side panels are on Florida whereas the right-hand side panels are on Ohio. Figure 1 shows that in each data set one outlier exists. For Florida, Miami-Dade County, where Miami is located, has both a large number of coronavirus cases and a large population. For Ohio, the outlier is Marion county, in which more than 1000 people contracted the virus at a state prison. As is shown below, the existence of these outliers has little effect on our estimation results.

All election data is from the New York Times site. Florida population estimates for 2019 are from the Office of Economic and Demographic Research of the Florida

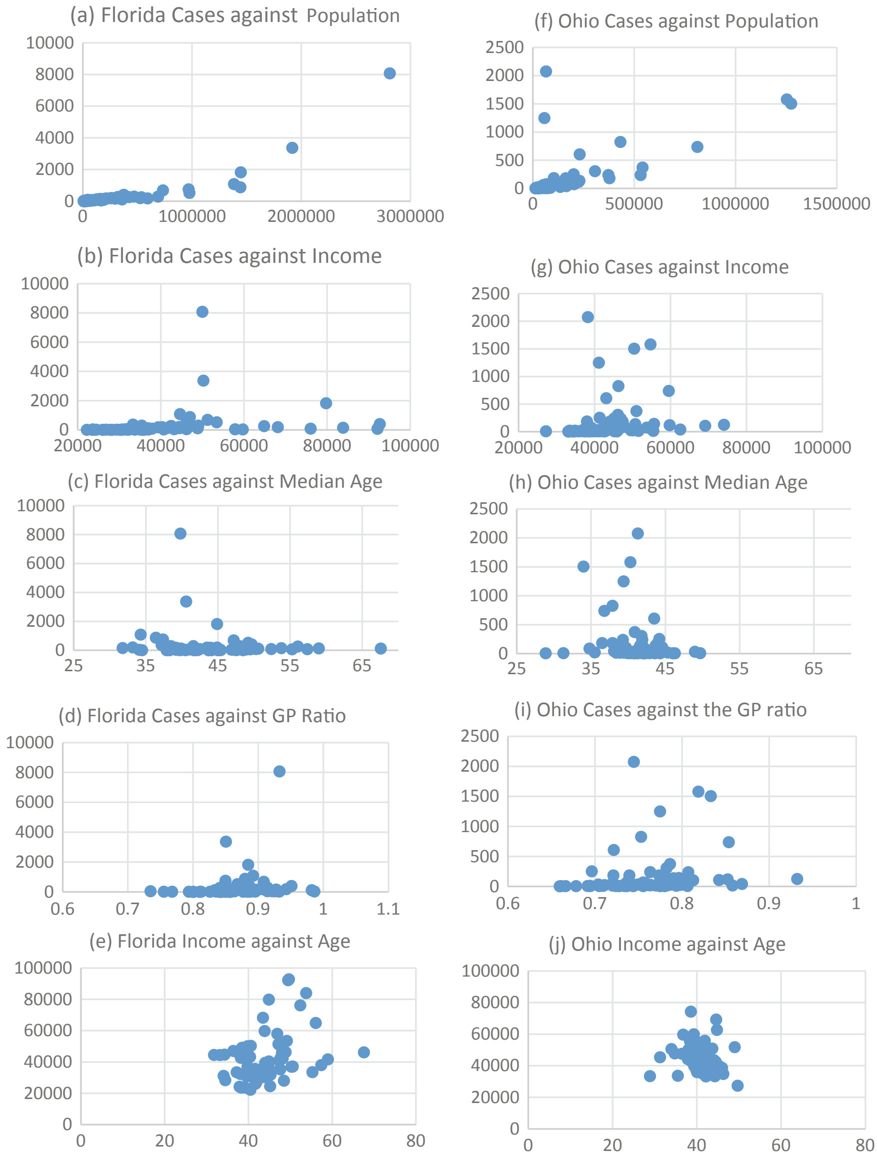

Fig. 1 Descriptive statistics

Legislature.[4] Ohio population estimates are from Ohio Demographics at the Cubit site.[5] County area data is from the site of Florida Association of Counties for Florida

[4] http://edr.state.fl.us/Content/population-demographics/data/index-floridaproducts.cfm.

[5] www.ohio-demographics.com/counties_by_population.

and from the USA.com site for Ohio.[6] Data on the number of cities is from the Florida Association of Counties site for Florida and from Wikipedia (list of cities in Ohio) for Ohio.[7] Data for instrumental variables are from the following sites. Education data from the Town Charts.[8] Median home value and average property tax data for Florida from the Smart Asset site.[9] Data for control variables are from the following sites. Median home value data for Ohio from the Cleveland.com site.[10] Urban and rural population density data from 2010 Census Urban and Rural Classification and Urban Area Criteria.[11] Florida water area data from the USA.com site.[12] Per capita income data from the US Department of Commerce, Bureau of Economic Analysis (2018).[13] Wage rate data from the US Bureau of Labor Statistics site.[14] Poverty data from Sandoval (2015, percentage of poor) for Florida and from the Index Mundi site for Ohio.[15] Data on the number of hospitals from Wikipedia.[16]

5 Possible Determinants of the COVID-19 Spread

5.1 Acceleration Effect of Population

To capture the determinant of the COVID-19 spread, we estimate several different models. The first is the single explanatory variable model. That is, we estimate the number per capita of COVID-19 cases on one of the demographic and economic factors considered here, that is, population, population density, the number of cities in a county, per capita income, education level, median-home value, wage rate, the area of a county, the number of hospitals, and poverty level. The estimation equation is.

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[6] www.fl-counties.com/county-population-and-general-information and www.usa.com/rank/ohio-state--land-area--county-rank.htm.

[7] www.fl-counties.com/florida-cities-county and https://en.wikipedia.org/wiki/List_of_cities_in_Ohio.

[8] www.towncharts.com/United-States-Education-data.html.

[9] https://smartasset.com/taxes/florida-property-tax-calculator.

[10] www.cleveland.com/datacentral/2017/12/ranking_every_ohio_city_county_9. html.

[11] www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural/2010-urban-rural.html.

[12] www.usa.com/rank/florida-state--water-area--county-rank.htm?yr=9000&dis=&wist=&plow=&phigh =

[13] www.bea.gov/data/income-saving/personal-income-county-metro-and-other-areas.

[14] www.bls.gov/regions/southeast/news-release/countyemploymentandwages_florida.htm.

[15] www.indexmundi.com/facts/united-states/quick-facts/ohio/percent-of-people-of-all-ages-in-poverty#table.

[16] List of hospitals in Florida and in Ohio: https://en.wikipedia.org/wiki/List_of_hospitals_in_Florida and https://en.wikipedia.org/wiki/List_of_hospitals_in_Ohio, downloaded in May 2020.

$$n = c + \beta_o[one\ \ social\ \ factor], \tag{2}$$

where the dependent variable is the number of COVID-19 cases per capita in a county, $n = N/P$, where N and P are the number of cases in county and the population of the county, respectively.

Table 1a summarizes the estimation results. This shows that the number per capita of COVID-19 cases are significantly correlated to the socio-economic factors considered in this study. Many of these correlations are, however, absorbed by population.

That is, once we include population in addition to one of the factors, the correlation with the latter factor disappears. That is, we estimate

$$n = c + \beta_P P + \beta_o[another\ \ explanatory\ \ factor]. \tag{3}$$

Table 1a Factors contributing to the outbreak in an early stage in Florida. Dependent variable: Per capita cases in Florida counties (# of observation = 67)

1		2		3	
Constant	0.0004*** (7.83)	Constant	0.0005*** (7.62)	Constant	0.0004 (6.26)
Population	5.83E−10*** (6.54)	Population density	2.66E−7***	Number of cities	2.92E−5***
R2	0.4	R2	0.12	R2	0.22
4		5		6	
Constant	0.0002 (1.03)	Constant	0.0002 (1.55)	Constant	0.0002 (1.31)
Income per capita	1.03E−8*** (4.28)	Education	1.83E−5*** (3.26)	Home value (Median)	2.90E−9*** (3.65)
R2	0.12	R2	0.14	R2	0.17
7		8		9	
Constant	−0.0003 (−1.20)	Constant	0.0004* (1.97)	Constant	0.0004*** (7.02)
Wage	1.23E−6*** (3.34)	Area	4.42E−7*** (3.12)	Hospitals (number)	0.0000*** (5.25)
R2	0.15	R2	0.12	R2	0.3
10					
Constant	0.0004 (7.02)				
Poverty	0.000*** (5.25)				
R2	0.3				

The values in () are t values (***, **, and * for 1% significance, 5% significance and 10% significance, respectively)

The estimation results are summarized in Table 1b. The table shows that once population is included in the estimation, most of the other explanatory variables become insignificant except for population density and the leader index.

In all estimation results, the number of per capita cases is positively correlated to population. This implies, by $n = N/P$, that column 1 in Table 1a, for example, gives rise to

Table 1b Factors contributing to the outbreak in an early stage in Florida:. Joint effects with population. Dependent variable: Per capita cases in Florida counties (# of observation = 67)

1		2		3	
Constant	0.0004*** (8.28)	Constant	0.0005*** (7.31)	Constant	0.0004* (1.7)
Population	5.83E−10*** (6.54)	Population	7.7E−10*** (3.4)	Population	6.4E−10*** (4.4)
		Population density	−2.28E−7** (−2.05)	Number of cities	−4.8E−6 (−0.49)
R2	0.4	R2	0.44	R2	0.40
4		5		6	
Constant	0.0002*** (3.0)	Constant	0.0003** (2.17)	Constant	0.0002** (1.61)
Population	5.35E−10*** (5.79)	Population	5.5E−10*** (5.29)	Population	5.1E−10*** (5.43)
Income per capita	5.0E−9* (1.7))	Education	4.0E−6 (0.74)	Home value (Median)	1.4E−9* (1.9)
R2	0.43	R2	0.41	R2	0.43
7		8		9	
Constant	0.0005 (−1.20)	Constant	0.0004**** (1.97)	Constant	0.0004*** (7.02)
Population	6.0E−10*** (5.15)	Population	5.6E−10*** (5.34)	Population	9.1E−10*** (3.62)
Wage	−7.3E−8 (−0.18)	Area	6.0E−8 (0.43)	Hospitals (number)	−3.4E−5 (−1.4)
R2	0.40	R2	0.40	R2	0.42
10					
Constant	0.0004*** (7.02)				
Population	9.1E−10*** (3.62)				
Poverty	−3.4E−5 (−1.4)				
R2	0.42				

The values in () are t values (***, **, and * for 1% significance, 5% significance and 10% significance, respectively)

$$N_j = 41.5\left(\frac{P_j}{10^5}\right) + 5.8\left(\frac{P_j}{10^5}\right)^2 \tag{4}$$

This shows that, as population increases, the coronavirus cases increase with an acceleration rate of 11.6 people per 10,000 people. All the other estimations show that the coefficient on P^2 is significant, mostly at the 1% level and positive. This is consistent with the theoretical prediction that if people would believe leaders who downplay the danger of an epidemic, the epidemic would spread in a natural manner. In the literature on epidemiology, it has been established that the spread of the outbreak accelerates with population at its early stage (see Kermack and McKendrick (1927)).

Finding 1 In Florida, the spread of COVID-19 cases accelerates with county population at an acceleration rate between 9 and 14 per 10,000 people with/without control variables included.

5.2 Pandemic Suppressing Effect of Population Density

See Table 1b. An important finding in the previous model, (3), is that the significant effects of population density D and the leader index R, defined by (1). Section 2. That is, leader index R is positively correlated to the number per capita of COVID-19 cases. This suggests that the presence of core Trump supporters worsens the contagion.

Even more interesting is the finding that population density is negatively correlated to the number per capital of cases. As is discussed in the Introduction, if people realized that COVID-19 spreads more readily in a more populated area, they might put more self-protective efforts. Our finding is consistent with this possibility.

With these considerations, in this section, we add population density D and leader index R in our estimation equation, which is

$$n = c + D + R + \beta_P P + \beta_o[another\ explanatory\ factor]. \tag{5}$$

Table 1c summarizes the results. An important finding is that once population, population density and the president/governor ratio are controlled, each of the other explanatory variables loses explanatory power completely. This suggests that model (5) fits our data better than models (2) and (3). At the same time, the effect of the leader index remains significant and positive.

The effect of population density remains significant and negative. This sharply contrasts with the common intuition that, as population density increases, the chance of contracting an epidemic would become higher.

One possible reason might be that population density (population per square mile) may not capture how crowded a particular region actually is. With this consideration,

Table 1c Factors contributing to the outbreak in an early stage in Florida: Joint effects with population, population density, and G/P ratio. Dependent variable: Per capita cases in Florida counties (# of observation = 67)

1		2		3	
Constant	−0.0021*** (−2.86)	Constant	−0.0022*** (−2.92)	Constant	−0.0022*** (−2.87)
Population	5.24E−10*** (6.24)	Population	7.2E−10*** (6.09)	Population	7.1E−10*** (4.48)
		Population density	−2.29E−7** (−2.26)	Population density	−2.29E−7** (−2.9)
G/P ratio	0.0030*** (3.41)	G/P ratio	0.0030*** (3.53)	G/P ratio	0.0027*** (3.47)
				Number of cities	5.55E−7 (0.06)
R2	0.49	R2	0.53	R2	0.53
4		**5**		**6**	
Constant	0.0020*** (−2.6)	Constant	−0.0022** (−2.73)	Constant	−0.0020** (−2.63)
Population	7.1E−10*** (5.96)	Population	7.2E−10*** (6.01)	Population	6.9E−10*** (5.67)
Population density	−2.37E−7** (−2.32)	Population density	−2.25E−7** (−2.1)	Population density	−2.31E−7** (−2.27)
G/P ratio	0.0031*** (2.93)	G/P ratio	0.0027*** (3.13)	G/P ratio	0.0032*** (3)
Income per capita	2.22E−9 (0.75))	Education	−8.220E−7 (−0.15)	Home Value (Median)	7.06E−10* (1.01)
R2	0.53	R2	0.53	R2	0.54
7		**8**		**9**	
Constant	−0.0019** (−2.38)	Constant	−0.0021*** (−2.81)	Constant	−0.0022*** (−2.86)
Population	7.9E−10*** (5.8)	Population	8.3E−10*** (5.13)	Population	7.0E−10*** (2.96)
Population density	−1.96E−7* (−1.85)	Population density	−2.95E−7** (−2.45)	Population density	−2.33E−7* (−1.99)
G/P ratio	0.0032*** (3.68)	G/P ratio	0.0031*** (3.57)	G/P ratio	0.0030*** (3.46)
Wage	−6.25E−7 (−1.08)	Area	−1.47E−7 (−1.01)	Hospitals (number)	1.79E−6 (0.07)
R2	0.54	R2	0.54	R2	0.53

(continued)

Table 1c (continued)

10					
Constant	−0.0020***				
	(−2.48)				
Population	7.2E−10***				
	(6.1)				
Population density	−2.28E−7** (−2.23)				
G/P ratio	0.0029***				
	(3.36)				
Poverty	5.53E−9				
	(0.73)				
R2	0.53				

The values in () are t values (***, **, and * for 1% significance, 5% significance and 10% significance, respectively)

we estimate (2) by controlling urban and rural population and water area. Table 2a shows, however, that even if they are controlled, the negative effect of population density persists whereas urban and rural population densities and water area are insignificant for all but one specification. Another possible explanation may be that the negative correlation is due to the outlier (Miami-Dade) in the dataset. As Table 2b shows, in fact, population density becomes insignificant if Miami-Dade County is excluded.

Finding 2 A higher population density leads to a fewer number per capita of COVID-19 cases.

5.3 Pandemic Suppressing Effect of Urbanization

As is discussed above, congestion might lead people to behave more carefully against the COVID-19 outbreak, thereby negatively affecting the per capita cases. This result may be reinforced by including in estimation the degree of urbanization in a county, K, which is measured by the number of cities, and the augmented population by the degree of urbanization, that is, $K \cdot P$, where K denotes the number of cities in a county. Equation (5) now becomes

$$n = c + \beta_K K + \beta_{KP} K \cdot P + \beta_D D + \beta_P P + \beta_o \tag{6}$$

Columns 1 through 3 of Table 3 summarizes the estimation results for various combinations of explanatory variables, population P and effective population $K \cdot P$.

Table 2a Effects of missing geographic factors and Miami-Dade (Outlier) in Florida: without Miami

	0	1	2	3	4	5
Constant	0.0004***	0.0004***	0.0003**	0.0002	0.0002	0.0001
	(7.83)	(8.43)	(2.39)	(1.45)	(1.39)	(0.81)
Population	5.8E−10***	7.7E−10**	5.8E−10***	5.9E−10***	6.6E−10***	6.3E−10***
	(6.54)	(6.13)	(3.29)	(3.31)	(3.34)	(3.18)
Population density		−2E−07***	−2.7E−7**	−3.14E−7**	−3.2E−7**	−3.1E−7**
		(−2.07)	(−2.41)	(−2.22)	(−2.21)	(−2.19)
Urban population			1.5E−7	1.7E−7	1.8E−7*	1.7E−7
			(1.59)	(1.66)	(1.74)	(1.61)
Rural population				1.0E−6	1.0E−6	8.4E−8
				(0.51)	(0.51)	(0.04)
Water					6.4E−8	2.2E−8
					(0.48)	(0.16)
Number of cities					−8.1E−6	−8.4E−6
					(−0.83)	(−0.85)
Poverty						1.0E−8
						(1.23)
Education						7.0E−6
						(1.27)

(continued)

Table 2a (continued)

	0	1	2	3	4	5
Miami dummy						
R2	0.4	0.45919	4.59E-01	0.4614833	0.4690973	0.4952062

The second rows report *t* values (***, **, and * for 1% significance, 5% significance and 10% significance, respectively)
Dependent Variable: Per Capita Coronavirus Cases in Florida Counties (Number of Observations = 67)

Table 2b Effects of missing geographic factors and Miami (Outlier) in Florida: With Miami

	6	7	8	9	10	11
Constant	0.0004***	0.0005***	0.0004***	0.0003**	0.0003*	0.0002
	(8.98)	(9.04)	(3.01)	(2.03)	(1.92)	(1.29)
Population	3.9E−10***	5.1E−10***	4.4E−10**	4.5E−10**	5.0E−10**	4.1E−10*
	(3.64)	(3.15)	(2.36)	(2.38)	(2.38)	(1.92)
Population density		−1.2E−7	−1.6E−7	−2.0E−7	−2E−7	−2E−7
		(−1.04)	(−1.27)	(−1.29)	(−1.32)	(−1.17)
Urban population			8.5E−8	9.7E−8	1.1E−7	6.9E−8
			(0.85)	(0.93)	(0.99)	(0.64)
Rural population				8.6E−7*	9.4E−7	−4E−7
				(0.44)	(0.46)	(−0.18)
Water					6.3E−8	−3E−9
					(0.49)	(−0.03)
Number of cities					−5.5E−6	−5E−6
					(−0.57)	(−0.48)
Poverty						9.8E−9
						(1.23)
Education						1E−5
						(1.89)
Miami dummy	0.0013	0.0011	0.0010	0.0010	0.0009	0.0012
	(3.04)	(2.40)	(1.95)	(1.92)	(1.79)	(2.25)
R2	0.4756	0.4845	0.4904	0.4920	0.4965	0.5364

The second rows report t values (***, **, and * for 1% significance, 5% significance and 10% significance, respectively)
Dependent Variable: Per Capita Coronavirus Cases in Florida Counties (Number of Observations = 67)

In order to check multicollinearity, we report the vif values on each coefficient in double parentheses; we report only results in which the vif values are all smaller than 10, which suggests that multicollinearity does not pose a serious problem.

The results in Table 3 show that once effective population $K \cdot P$ is included, neither population P nor population density D is significant any more. Columns 4 and 5 of Table 4 show that urbanization factor K alone does not have a similar effect.

These results suggest that the main factors related to the number per capita of COVID-19 cases are urbanization K and urbanization-adjusted population $K \cdot P$. The last model we examine, therefore, includes only these variables with other control variables. The estimation equation is.

$$n = c + \beta_K K + \beta_{KP} K \cdot P + \beta_o[control\ variables] \quad (7)$$

Table 3 Population or urbanization

	1	2	3	4	5
Constant	0.0005***	0.0005***	0.0006***	0.0005***	0.0005***
	(8.76)	(8.87)	(8.70)	(8.87)	(7.84)
Population	1.4E−10	3.3E−10	2.3E−10	6.3E−10***	8.2E−10***
	(0.74)	(1.36)	(0.97)	(4.36)	(4.87)
	((4.7))	((8.3)	((8.5))	((2.7))	((3.7))
Population density		−1.4E−7	−4.5E−8		-2.3E−7**
		(−1.23)	(−0.39)		(-2.05)
		((2.4))	((2.7))		((2.1))
Effective population (KP)	1.7E−11***	1.4E−11**	2.8E−11***		
	(2.73)	(2.12)	(3.33)		
	((4.7))	((5.4))	((9.6))		
Urbanization (K)			−3E−05**	−4.4E−06	−3.9E−06
			(−2.53)	(−0.45)	(−0.41)
			((4.7))	((2.7))	((2.7)))
R2	0.46	0.48	0.52	0.48	0.44

The second rows report *t* values (***, **, and * for 1% significance, 5% significance and 10% significance, respectively)
The third rows report vif values
Dependent Variable: Per Capita Coronavirus Cases in Florida Counties (Number of Observations = 67)

Table 4 Effects of urbanization and urbanization adjusted population

	1	2	3	4
Constant	0.0005	0.0004	0.0005	0.0004
	(4.25)	(3.15)	(4.18)	(3.04)
Effective population	3.1E−11	3.6E−11	3.1E−11	3.4E−11
	(4.79)	(5.63)	(3.22)	(3.67)
Urbanization	−3.25E−05	−3.872E−05	−3.275E−05	−3.7E−5
	(−2.91)	(−3.60)	(−2.32)	(−2.74)
Water area	9.0E−8	4.0E−8	9.1E−8	3.6E−8
	(0.75)	(0.35)	(0.75)	(0.31)
Urban pop density	7.4E−8	−3.8E−9	7.4E−8	−6.5E−9
	(0.91)	(−0.05)	(0.90)	(−0.08)
Poverty		1.1E−8		1.1E−8
		(1.56)		(1.53)
Education		1.2E−5		1.3E−5
		(2.73)		(2.71)
Miami dummy			−1.6E−5	0.0002
			(−0.03)	(0.26)
R2	0.5276	0.5922	0.5276	0.5926

The second rows report *t* values (***, **, and * for 1% significance, 5% significance and 10% significance, respectively)
Dependent Variable: Per Capita Coronavirus Cases in Florida Counties (Number of Observations = 67)

Table 4 summarizes estimation results. The first four columns are with all data and the second four columns are without Miami-Dade data. With or without Miami Dade County, the coefficients on effective population, urban factor (the number of cities), and education are all significant at the 1% level. The coefficient on urban factor is negative, which we may capture the preventive effect of congestion against COVID-19 infection.

In all estimations, effective population $K \cdot P$ is positively correlated to the number per capita of COVID-19 cases. In contrast, urbanization K is negatively correlated to it. This suggests that those who live in a county with a high level of urbanization tend to contract COVID-19 less. This suggests that people might learn from the experience of northeastern states and make more self-protection efforts.

Finding 3 A higher urbanization leads to a fewer the number per capita of COVID-19 cases.

6 Determinants of the Pandemic: Political Leadership and Self-Protection

The results summarized in Tables 3 and 4 suggest that we may replace population P and population density D by effective population $K \cdot P$ and urbanization factor K. With this consideration, we now investigate whether or not the number of coronavirus cases per capita is positively influenced by the core Trump supporters, unbanization, and urbanization adjusted population. Our estimation equation is

$$n = c + \beta_{GP} R + \beta_K K + \beta_{KP} K \cdot P + \beta_o[control\ variables] \tag{8}$$

Voting behaviour and self-protection behaviour against COVID-19 might be simultaneously determined by some missing variables, political beliefs, types of information that voters receive from media, among others. In order to cope with this endogeneity problem and to find a causality between the core Trump supporters and the COVID cases, we adopt the property tax of a county as an instrumental variable for the leader index. Because the property tax was determined before the COVID-19 pandemic, it is unlikely that the property tax of a county directly affects the number per capital of COVID-19 cases in the county. Thus, the property tax is a very good candidate for an instrumental variable for the leader index.

Table 5 presents an estimation result, which clears standard tests for instrumental variable estimation. As the table shows, the effects of the core Trump supporters, effective population, and urbanization are all significant; the number per capita of COVID-19 cases may be expressed as.

$$n = -0.0043013 - 2.83E^{-11}(812701 - P)K + 0.00570R. \tag{9}$$

This shows that an increase in the leader index leads to a higher number per capita of COVID-19 cases.

Finding 4 Political leadership matters in the fight against the COVID-19 pandemic.

Equation (9) captures the preventive effect of urbanization against COVID-19. That is, the number of per capita cases decreases with urbanization (an increase in K) among the counties with populations smaller than the cutoff value of 812701. Of the 67 Florida counties, Miami Dade County has the largest population (2,812,130), followed by Broward (1,919,644), Palm Beach (1,447,857), Hillsborough (1,444,870), Orange (1,386,080), Pinnella (978,045), Duval (970,672), and Polk (690,606). Thus, we may summarize this finding as follows:

Finding 5 Except for the seven most populated counties, the preventive effect of urbanization against COVID-19 exists; that is, the higher the degree of urbanization, the smaller the number of per capita COVID-19 cases, if other factors are kept constant.

Table 5 Effects of urbanization and urbanization adjusted population

	1	2	3	4
Constant	0.0005	0.0004	0.0005	0.0004
	(4.25)	(3.15)	(4.18)	(3.04)
Effective population	3.1E−11	3.6E−11	3.1E−11	3.4E−11
	(4.79)	(5.63)	(3.22)	(3.67)
Urbanization	−3.25E−05	−3.872E−05	−3.275E−05	−3.7E−5
	(−2.91)	(−3.60)	(−2.32)	(−2.74)
Water area	9.0E−8	4.0E−8	9.1E−8	3.6E−8
	(0.75)	(0.35)	(0.75)	(0.31)
Urban pop density	7.4E−8	−3.8E−9	7.4E−8	−6.5E−9
	(0.91)	(−0.05)	(0.90)	(−0.08)
Poverty		1.1E−8		1.1E−8
		(1.56)		(1.53)
Education		1.2E−5		1.3E−5
		(2.73)		(2.71)
Miami dummy			−1.6E−5	0.0002
			(−0.03)	(0.26)
R2	0.5276	0.5922	0.5276	0.5926

The second rows report *t* values (***, **, and * for 1% significance, 5% significance and 10% significance, respectively)
Dependent Variable: Per Capita Coronavirus Cases in Florida Counties (Number of Observations = 67)

7 Unique Environments Surrounding Florida

Our results show the importance of political leadership, in particular national political leadership, and self-protection in the fight against COVID-19. We believe it unlikely to obtain similar results with data other than Florida; there is no other industrial state in the US that is surrounded by the sea. Because Florida is surrounded almost completely by the sea, it eliminates potential noises that may dampen the effect of political and social learning factors. Moreover, Florida happened to have the gubernatorial election in 2018 and elected a Republican governor, who strongly supports President Trump, who is also a Republican. Unless these two conditions were not met, it would have been difficult to capture our results.

In order to double check this possibility, we study Ohio by the same method. Ohio elected a Republican governor in 2018, Governor Dewine. However, Governor Dewine has maintained a distance from the president since the time of his election.[17]

[17] See Gomez (2018).

Ohio was the first to close schools in the middle of March.[18] In April 2020, it was considered to be one of the more successful states in controlling the virus.[19]

To check these differences matters, we make the same estimations with Florida data. The estimation results on models (1), (2) and (4) by using Ohio data show that almost no variables have significant effects; see Yano (2020, Tables 1 and 2) for details. This suggests that Florida is uniquely suited for the purpose of our study.

8 Conclusion

Our results show that political and demographic factors are important in determining the way in which COVID-19 spreads. In a state in which both local and national leaders downplay the danger of the virus, the number of per capita coronavirus cases increases with the number of core supporters of the national leader (Finding 4). At an early stage, the outbreak spreads in a natural manner, accelerating with population (Finding 1). Except for a handful of highly populated counties, urbanization reduces the number of per capita coronavirus cases (Finding 5). No such effects emerge in a state in which the local governor took a careful approach, as shown by Ohio data.

This result may be interpreted as follows. If both local and national leaders downplay the danger of the virus, their core supporters may be led to become less careful against the virus. At the same time, many people compensate for inadequate information and take their own self-protective measures, which may explain the preventive effect of urbanization against COVID-19 observed in most of the Florida counties (except the seven most populated counties).

Developing a cheap-talk game, Honryo and Yano (2020) show that a government can easily manipulate information if the government cares how the public perceives the government's performance. This theoretical prediction is empirically supported by our results as well as the recent work of Ajzenman et al. (2020), Bursztyn et al. (2020), and Brzezinski et al. (2020). The recent work of Blickle (2020) indicates that the future course of a society can be badly affected by a pandemic. Our result suggests the importance of transparency in the information provided by the government.

References

Adolph C, Amano K, Bree BJ, Fullman N, Wilkerson J (2020) Pandemic politics: timing state-level social distancing responses to COVID-19. medRxiv

Ajzenman N, Cavalcanti T, Da Mata D (2020) More than words: leaders' speech and risky behavior during a pandemic. CEPR DP14707

Allcott H, Boxell L, Conway J, Gentzkow M, Thaler M, Yang D (2020) Polarization and public health: partisan di erences in social distancing during COVID-19. NBER Working Paper 26946, NBER

[18] Camera (2020).

[19] It has a much smaller number of cases in comparison with some of the neighboring industrial state; for example, as of May 2, 2020, the number of cases is 19,335 in Ohio whereas it is 50,983 in Pennsylvania, 42,348 in Michigan, 56,055 in Illinois, and 18,941 in Indiana.

Andersen M (2020) Early evidence on social distancing in response to COVID-19 in the United States. SSRN, downloaded at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3569368 on April 23, 2020

Barrios J, Hockberg Y (2020) Risk perception through the lens of politics in the time of the COVID-19 pandemic. Becker Friedman Institute Working Paper No. 2020–32, University of Chicago

Blake A (2020) 2 months in the dark: the increasingly damning timeline of Trump's coronavirus response. Washington Post, April 22, 2020

Blickle K (2020) Pandemics change cities: municipal spending and voter extremism in Germany, 1918–1933. Staff Report No. 921, Federal Reserve Bank of New York

Brzezinski A, Kecht V, Van Dijckel D, Wright A (2020) Belief in science influences physical distancing in response to COVID-19 lockdown policies. Becker Friedman Institute for Economics Working Paper, No. 2020–56, University of Chicago

Bursztyn L, Rao A, Roth C, Yanagizawa-Drott D (2020) Misinformation during a pandemic. becker friedman institute for economics working paper 2020–44, University of Chicago

Camera L (2020) Ohio Gov. Mike DeWine Orders All K-12 schools closed: the state becomes the first to close all schools in the face of the COVID-19 outbreak. U.S. News, March 12

Fetzer T, Hensel L, Hermle J, Roth C (2020) Coronavirus perceptions and economic anxiety. arXiv preprint arXiv:2003.03848.

Gomez H (2018) Donald trump will hold an ohio rally the day before the midterms. In: The republican candidate for governor there is a maybe. BuzzFeed News, Oct 31

Honryo T, Yano M (2020) Idiosyncratic information and vague communication. Amer Political Sci Rev 115–1:165–178

Kermack W, McKendrick A (1927) A contribution to the mathematical theory of epidemics. In: Proceedings of the royal society A, pp 700–721

Luscombe R (2020) Florida's slow response: a "mini-Trump" governor who borrowed the president's playbook. Guardian, April 5, 2020

Nazaryan A (2020) How the coronavirus undid Florida Gov. Ron DeSantis. Yahoo News, May 4, 20

Sandoval H (2015) Poverty and income in Florida. University of Florida, Bureau of Economic and Business Research and Department of Economics

Sato M, Ota R, Ito A, Yano M (2020) Three minds equal Manjushari's Wisdom: an anatomy of informal social learning with heterogenous agents by the hierarchical bayesian approach. RIETI DP 20-E-092

Wright A, Sonin K, Driscoll J, Wilson J (2020) Poverty and economic dislocation reduce compliance with COVID-19 shelter-in-place protocols. Becker Friedman Institute for Economics Working Paper, 2020–40, University of Chicago

Yano M (2020) Covid-19 pandemic and politics: the cases of Florida and Ohio. RIETI DP 20-E-40

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Chapter 3
Integrating Social Sciences to Mitigate Against Covid

Richard Paul, Olivier Telle, and Samuel Benkimoun

Abstract The SARS-CoV-2 pandemic has led to the implementation of unprecedented public health intervention measures, not least the lockdown of countries worldwide. In our hyperconnected world exemplified by social media, it is now possible to derive quantitative measures of human mobilities at useful spatial scales. In this chapter we discuss how the use of Facebook data enables us not only to capture the impact of lockdown on human mobility but also to assess how changes in mobility contribute to the spread of the virus. By performing a comparative analysis across four countries of differing levels of lockdown—Sweden, US, France and Colombia—we show that mobility contributes a substantial amount to the spread of the disease. This contribution is strongest when the local number of cases is low, but, importantly, is maintained even when the virus is widespread. Current epidemiological models do not take into account such mobility patterns and yet there exists a developed theoretical framework within which mobility can be included. Inclusion of mobility data would allow public health authorities to focus on highly connected hubs of infection and, because mobility patterns are relatively stable over time, would also enable forecasting of how the spread of this or another novel virus is going to occur. Anticipating epidemics and their spread is key for developing suitable but targeted intervention strategies and avoiding draconian lockdowns that are so harmful to the economy.

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1 Introduction

100 years after the 1918 Spanish flu pandemic, we are currently struggling to contain the inexorable spread of the novel coronavirus (SARS-CoV-2). In December 2019, a cluster of pneumonia cases of unknown etiology emerged in the city of Wuhan, some of which were connected to a food market, in the Chinese province of Hubei (WHO 2020a). On January 9, 2020, the Chinese health authorities and the World Health Organization (WHO 2020a) officially announced the discovery of a novel coronavirus, 2019-nCoV, now known as SARS-CoV-2 (Zhou et al. 2020; Zhu et al. 2020). The suspected food market had already been shut down on January 1, but with an increasing number of cases, the Chinese authorities put Wuhan and subsequently all 15 cities in Hubai province into a lockdown of unprecedented levels, affecting about 57 million people for over two months. Such an unparalleled public health response was likely influenced by the previous other two novel coronavirus outbreaks: the severe acute respiratory syndrome coronavirus SARS-CoV 2003 and the Middle East respiratory syndrome coronavirus MERS-CoV 2012, which had estimated associated case fatality ratios of 11% and 35% respectively (WHO 2003, 2019). SARS-CoV-2 then spread globally and, faced with rapidly overburdened health systems, countries worldwide, for the most part, followed suit, by imposing increasingly stringent confinement policies and leaving governments facing the challenge of balancing immediate health and economic costs (Anderson et al. 2020; Fisher and Wilder-Smith 2020; Gates 2020; McKee and Stuckler 2020). The implementation of such extreme and widespread imposed lockdowns is unprecedented and yet, along with individual social distancing measures, these and other non-pharmaceutical interventions (NPIs) have a rich history in the public health response to infectious diseases. Despite our technological, scientific, and medical progress, we still have recourse to centuries old methods to mitigate against COVID-19 while awaiting the development of effective drugs and/or vaccines. As WHO Director-General Dr. Tedros stated: “we have a long way to go. This virus will be with us for a long time” and “the world cannot go back to the way things were. There must be a ‘new normal’—a world that is healthier, safer and better prepared” (WHO 2020b). In this chapter, we discuss how integration of a social sciences perspective into the more classical epidemiological approach to study infectious diseases could contribute to the development of a more efficient framework to mitigate against such large-scale outbreaks.

2 Public Health Intervention Measures

The current widely implemented NPIs include measures to reduce contact between individuals in an attempt to prevent any potential transmission at several scales: (1)

a mass scale (sanitary cordons to prevent people leaving or entering the infected area); (2) an intra-city scale (closures of educational establishments, businesses, and restaurants); (3) a more familial level (banning of social gatherings and mixing between houses); and (4) an individual level (testing of incoming travellers, tracing of contacts of cases, isolation, and self-quarantine).

2.1 Testing, Track and Trace

Considerable attention has been paid to their relative utility and efficacy in reducing the disease burden and when to implement which approach—what is the best strategy. Robust testing capacity, prompt isolation of cases, and timely and effective tracing of individuals who have had contact with a known case and their subsequent quarantine, along with social distancing, are currently the main pillars of the European COVID-19 public health response (ECDC 2020a). Over the course of the COVID-19 pandemic, testing strategies across Europe focussed primarily on individuals with symptoms that were clinically compatible with SARS-CoV-2 infection. These included many symptoms widely shared by respiratory infections (fever, diarrhoea, cough, dyspnoea, headaches, and confusion), as well as unusual symptoms, notably odynophagia (pain when swallowing), ageusia (loss of sense of taste), and anosmia (loss of sense of smell). In addition, testing has been widely implemented for individuals in high-risk groups (for example, healthcare workers, staff and residents of long-term care facilities), in accordance with the ECDC case definition, surveillance strategy and long-term care facility surveillance guidance (ECDC 2020b, c, d). Quantifying the utility of a range of different testing, isolation, tracing, and physical distancing scenarios in the UK revealed that combined isolation and tracing strategies would reduce transmission more than mass testing or self-isolation alone (Kucharski et al. 2020). If combined with moderate physical distancing measures, self-isolation and contact tracing would be the most likely approach to achieve control (Peak et al. 2020). However, it has been estimated that a high proportion of cases would need to self-isolate and a very large proportion of their contacts to be successfully traced to reduce the basic reproductive number, R_0 (the number of secondary infections from a single primary infection) to less than 1 in the absence of other measures. Although there is at present no global consensus, it is increasingly agreed, however, that contact tracing and testing is simply not possible when the epidemic is in full flow and that it can only be implemented when the number of infections is relatively low (Ferguson et al. 2020). Approaches that are more passive have been developed to aid in identifying contacts of cases in the form of phone apps (eHealth Network 2020). Attempts to encourage the general public to download and use phone apps have, however, had considerable teething problems and been met with little success and the number of asymptomatic infections throws into doubt to what extent trace and test is of use (Chidambaram et al. 2020). Testing of household members of cases is common, but random sampling from households, irrespective of whether a case was identified or not, has also been performed to assess the overall prevalence rates and estimate the extent to which infections are asymptomatic (Buitrago et al. 2020). One additional challenge in contact tracing is how quickly to test. The latency period (prior to detectable/transmissible virus in the individual) lasts 5–6 days (range 4–12 days) (Backer et al. 2020; Lauer et al. 2020; Petersen et al. 2020). Testing too early might therefore miss incubating infections. Crucial to the utility of isolation is knowledge of the latency and infectious periods, which consequently determine the length of the isolation period. Such information can only be gathered with experience, hence the initial uncertainty about the required period of self-isolation for individuals either coming from an infected area or having had contact with a confirmed case. Mass testing or population-wide testing has been carried out in many countries in several different ways. Testing of incoming travellers is common. Some countries have also set up drive-in testing centres for all, but with increasing numbers of cases, the logistics and cost of such an approach have rapidly become unviable and tests are now often restricted to those with COVID-like symptoms and contacts thereof. However, despite the logistical challenges, a pilot mass-testing approach was implemented in Liverpool, with the intention of rolling it out across the whole of England (Iacobucci 2020).

2.2 *Quarantine*

The isolation of infected individuals has been documented to have occurred since biblical times and throughout the middle ages, prior to the development of germ theory. The most extreme example of individual isolation is that of Typhoid Mary, a typhoid superspreader (see below), who was arrested and spent the last 20 years of her life in a prison hospital. Long-term isolation of individuals infected with leprosy is well known and enforced sanitary cordons around infected villages, towns and cities have been implemented since the fourteenth century when the first plague pandemic occurred (Porter 1998). Although often used interchangeably with *cordon sanitaire* (sanitary cordon), quarantine (derived from *quarantena*, the Venetian language form, meaning “40 days”) was first used as a measure of disease prevention related to the plague (Sehdev 2002). The individuals of arriving ships had to spend 30 days (later extended to 40) in specified isolation sites waiting to see whether the symptoms of plague would develop. This practice was subsequently used in the later plague epidemics and in an attempt to ward off the yellow fever and cholera epidemics of the nineteenth century (Sehdev 2002). More recently, thousands of individuals were put into quarantine during the 2003 SARS epidemic and home-based quarantine was carried out during the Ebola epidemic. This form of individual isolation based on testing for symptoms and/or contacts with known cases is currently used for the COVID-19 pandemic and its efficacy demonstrated in the case of the quarantine on the *Diamond Princess* cruise ship. It is thought that an infected individual boarded the vessel from Hong Kong late January, developed symptoms, and was tested positive for SARS-CoV2. On February 1, the ship was then placed in quarantine and by February 15 there were 285 cases. At this point, the passengers were disembarked and placed in quarantine units before repatriation. The final case count exceeded 700 out of a total of 3,711 passengers and staff and, through testing, 18% of infections were identified as being without symptoms (that is, asymptomatic) or with few symptoms (paucisymptomatic). The contagiousness of the virus was estimated to be four times higher than that in Wuhan, at least before passengers were confined to their cabins (Rocklöv et al. 2020). This underlines how contact rates (and conversely quarantine) can have a very large impact upon the spread of the virus and lead to a superspreading event (see below).

3 Fundamental Epidemiological Parameters and Superspreaders

Arguably, the most important measure in infectious disease epidemiology is the basic reproductive number, R_0: how many individuals will become infected by a single infected person (in a completely immune-naïve population). This gives a measure of the contagiousness of the pathogen and provides a metric to assess the efficacy of an intervention. Ideally, the aim of any intervention strategy is to reduce R to below one, at which point the pathogen would eventually die out. The R_0 of SARS-CoV-2 has been estimated to be 2.5–4 in China (Li et al. 2020a; Wu et al. 2020), Italy (Remuzzi and Remuzzi 2020), France (Salje et al. 2020) and across Europe generally (Flaxman et al. 2020). This means that transmission would need to be reduced by more than 60% to reduce R below 1 (Petersen et al. 2020). A study in the UK estimated that the observed 74% reduction in number of contacts per person during lockdown enabled a reduction of R from the pre-lockdown value 2.6 to below 1 (Jarvis et al. 2020). However, much higher values of R have been estimated in Oman, UK, and through a re-analysis of Wuhan, with values reaching as high as six (Al Wahaibi et al. 2020; Dropkin et al. 2020; Sanche et al. 2020).

Crucial parameters that determine R_0 are the duration of an infection and the infectious period. Infectiousness is estimated to start at the onset of symptoms and last 5–6 days, although viral shedding in hospitalized patients has been found to last as much as three weeks (Petersen et al. 2020; Zhou et al. 2020). However, there are high numbers of asymptomatic/paucisymptomatic infections and little is known about their infectiousness or the duration of such infections. A single point estimate in households suggests that not only are asymptomatics 65% as infectious as symptomatic individuals, but also they tend to lead to other asymptomatic infections (Kucharski et al. 2020). This may reflect a lower viral load in asymptomatic infections, but could also be influenced by human genetics, as household members are related.

Importantly, whilst R_0 gives an overall average of the contagiousness of the pathogen, the actual number of people infected by a single infected person will vary enormously. This can occur for a variety of reasons, whether due to individual innate characteristics (human genetics), viral load, or simply because some people have more contacts than others (Kucharski et al. 2020; Petersen et al. 2020). This latter is probably the most important feature determining pathogen transmission and likely influenced by age, behavioural gregariousness, type of work, and type of transport used. Thus while R_0 is a useful metric, it belies the actual transmission structure. Understanding the contribution of superspreading individuals, events, or places to the global case count is essential for developing appropriate intervention strategies and assessing the utility of approaches targeting potential reservoirs of infections.

The role of superspreading events is well documented in the literature and plays an important but variable role in pathogen transmission (Lloyd-Smith et al. 2005). During the 2003 SARS epidemic, one index case led to 292 secondary cases living in the same block of flats, mostly likely transmitted through the ventilation system (Yu et al. 2004). Superspreading events during the current pandemic have been notable, with many types of social gatherings (music festivals, church services), generating a large number of COVID cases (Ghinai et al. 2020; Hamner et al. 2020). Smaller clusters also occur within households, as might be expected from exposure in an enclosed space, and are probably more common than thought due to the large number of asymptomatic cases. As previously found for SARS 2003, nosocomial transmission is common as is transmission in care homes (Leclerc et al. 2020). While such superspreading events have led to the banning of public events, the tendency for pathogens to generate clusters varies significantly according to the pathogen in question, suggesting that both human behaviour and the nature of the infection itself are important. The extent to which the infections occur in clusters can be quantified as an aggregation parameter k, with small values (<1) indicating high clustering and values of 1 or larger an increasingly random distribution. For example, the k of SARS was estimated to be 0.16 and of MERS 0.25, indicating clustering. Estimates of SARS-CoV-2 are currently uncertain, but may be of the same order of magnitude, with an estimated 10% of the cases contributing to 80% of the spread (Endo et al. 2020). This disproportionate contribution to viral spread has been backed up by a recent study of more than a half million people in India who were exposed to SARS-CoV-2 (Laxminarayan et al. 2020). The report suggests that the continued spread of the virus was driven by only a small percentage of those who become infected. An estimated 71% of infected individuals did not infect any of their contacts, while a mere 8% of infected individuals accounted for 60% of new infections. In that study, they also found that close contact community level transmission was less important (2.6% transmission probability) than household transmission (9% probability). However, they also found that although high risk contact individuals (spending > 6 h in the same public transport as a case) did have higher risk of infection than low risk contact individuals, the difference was only marginal (10% vs 5% infection probability). Another study in the state of Georgia, US, estimated that 2% of infections were found to generate 20% of new infections and individuals <60 year olds contributed more than older individuals to transmission (Lau et al. 2020).

At local scales (that is, city, town, hospital, house), the significance of such heterogeneous infectiousness can be relatively easily understood and to some extent managed. Over a larger scale (county, region, country), however, it is less clear what this means for the spread of the pathogen and thus what measures should be taken.

4 Travel Restrictions and Mobility—The Value of Social Media and Mobile Phone Data

To this point, we have addressed how NPIs have been designed to slow the rate of viral transmission predominantly at a local level. One important feature of the response to the first wave was implementation of the sanitary cordon and placing draconian travel restrictions on the population to prevent the spread of the pathogen. The efficacy of this strategy lies in the timing of the implementation. The travel restrictions in Hubei have been estimated to have delayed the epidemic progression throughout China by only 3–5 days, probably because the virus had already been spread widely prior to the lockdown because of extensive travel linked to the Lunar New Year holiday (Gibbs et al. 2020). The sanitary cordon was likely therefore implemented too late and although human mobility data correlated well with the spatial spread of the pathogen prior to the travel restrictions, social distancing, and local measures to reduce contact became more important post lockdown (Kraemer et al. 2020). On a greater scale, however, the Hubei lockdown was estimated to have significantly delayed the spread of the virus internationally, where case importation was reduced by nearly 80% until mid-February (Chinazzi et al. 2020).

Key to understanding the efficacy of reduced contact intervention measures, whether travel restrictions or social distancing (including self-quarantine, reduced gatherings, stay-at-home orders), is being able to quantitatively measure the extent to which they are being adopted by the population and if there is variation in their adoption, whether by place (city size, rural vs. urban) or population strata (age, gender, economic status). The value of being able to quantitatively visualize mobility data at all geographical scales is many-fold and especially clear with respect to the COVID measures taken by governments. Mobility data and changes thereof can inform how people respond to imposed and imminent announcements of measures to be taken. For example, in many affected cities, there was a large efflux just before the announcement of the lockdown and particularly in those areas with highest rates (Pullano et al. 2020). In France, after the announcement of school closures, there was a considerable exodus from Ile-de-France to the countryside in neighbouring Normandy (Pullano et al. 2020). This represented the wealthier population with second homes or those with families in the countryside, with the intention to wait out the epidemic in more comfortable settings. Secondly, in near real time, the extent to which the lockdown is actually being effective can be observed and how the effects differ across geographical areas. Thirdly, the extent to which short and long (>100 km) distances moved can be differentiated: large distance movements will contribute to the spread of the epidemic across the region and country, whereas small distance movements will contribute to within-region epidemic levels. This in turn can inform about the potential flux of infectious individuals, in so far as the majority of the mobile working population will be part of the age range that is more likely to have subclinical infections.

One interesting example is Tokyo, Japan, where the justice system did not allow a mandatory lockdown. The government announced a non-compulsory remote working request at the end of February, followed quickly by closure of public schools. This entailed a significant decrease in mobility, as estimated through mobile phone data, even though there was no mandatory lockdown (Yabe et al. 2020). Subsequently on April 7, a state of emergency was announced, and this was followed by a rapid decrease in mobility at both an intra-Tokyo level and at longer distances. However, calculations of R suggested that the value was already low (~0.3) prior to the announcement, begging the question of the added value of this announcement and consequent public reaction. This would suggest a more nuanced response is warranted, although hindsight is of little value for decision-making. For this reason, worldwide, there was a tremendous effort to increase testing capacity to improve knowledge of the state of the epidemic and attempt to develop apps devices to improve track and testing of case contacts.

In our hyper-connected world there is extensive use of mobile phones, internet providers, and social media and there is currently much discussion on the use of such data to guide the public health response to COVID (Grantz et al. 2020). Within strict guidelines concerning personal privacy, several mobile phone operators, social network and internet service providers across the world have offered their data at an aggregated level to be able to visualize patterns of mobility and contact (Buckee et al. 2020; Pollina and Busvine 2020; Romm et al. 2020). Several different types of data can be generated, enabling varying levels of mobility and contact rates to be addressed. Firstly, call data records (CDRs) are routinely collected by operators and inform on an individual's movement (origin/destination) as indicated by proximity to the closest telephone tower. These capture the major components of human mobility: total trip distance (TTD), radius of gyration (RG) (characteristic distance travelled a person), and number of sites visited. Aggregated across a population, these data can reveal important features of larger-scale movement patterns and how the distribution of TTD, RG, and sites visited alters over time and place. Aggregated, anonymized, passively collected mobile phone data have previously used in infectious disease modelling of many infectious diseases, including cholera (Bengtsson et al. 2015; Finger et al. 2016), dengue (Wesolowski et al. 2015), Ebola (Peak et al. 2018), malaria (Wesolowski et al. 2012) and measles (Wesolowski et al. 2018) and more recently SARS-CoV-2 (Kraemer et al. 2020). The disadvantage of such data is their local imprecision, potential population bias, and dependency on telephone tower densities (Wesolowski et al. 2016). Secondly, many phone applications offer applications that will generate GPS location data, which enables many of the same advantages of CDRs, but allows more spatial precision. The disadvantage of such data is the bias in the user population (Wesolowski et al. 2016). Facebook falls into this category. These first two types of data are useful for quantifying large geographical scale population mobility patterns, predicting how the flux of the spread of a disease may occur and tracking how the components of mobilities change over time and place. The third type of data is Bluetooth data that records connections between two Bluetooth users. This offers much more detail on fine-scale population clustering and how, for example, intervention impacts upon social gatherings. Bluetooth data are clearly limited by user bias. Finally, many governments have endorsed opt-in applications that signal whether an individual has been in close proximity to a known infected case. This

Bluetooth-dependent approach was aimed to be of value for contact tracing but requires significant compliance by the population and the extent to which this will work is debatable. The EU drafted a recommendation on April 8, 2020 to develop a common EU toolbox for the use of technology and data to combat and exit from the COVID-19 crisis, in particular concerning mobile applications and the use of anonymized mobility data (European Commission 2020). An eventual aim of linking apps from all European countries was to enable better management of COVID across Europe to account for inter-country population mobility. To date 19 of 27 countries have developed an app, eight either have none or an app under development. Of all these actual or developing apps, 20 are potentially interoperable (can communicate with apps from other EU countries), but of which only six are currently so. The extent to which a Europe-wide system will actually be feasible before the end of the current pandemic remains to be seen, but at least the infrastructure will have been developed for future occasions of extreme events.

With so much quantitative data on movement and available case data on COVID infections from many countries, it should be possible to analyze the actual importance of reductions in mobilities on the spread of infection and whether light or hard lockdown should be implemented and under what circumstances (Benkimoun et al. 2020; Telle et al. 2021).

5 Quantifying the Impact of Travel Restrictions Using Facebook—Worked Examples

The majority of studies to date that have used mobility data have focussed on changing patterns of human mobility associated with confinement measures and a few have attempted to correlate this with alterations in key epidemiological parameters such as R_0. While useful, these approaches are indirect and yet it is possible to generate a much-improved understanding on the impact of human mobility on the spread and extent of the epidemic at geographical scales pertinent to public health responses. In the majority of countries worldwide, while there is general guidance by the central government to shape national health policies, governance and implementation of health measures is taken at the local scale, at an intermediary geographical scale. For the most part, however, government advisory panels at best categorize local administrative units into severity scales based on current numbers of infections and stress on the local health system without recourse to local inter-administrative unit mobility: that is, the classification of local epidemic severity and resilience of the local health system is neither dynamic nor predictive. This is surprising as we know that a significant proportion of infections are asymptomatic/paucisymptomatic, people will move across borders and thus will carry the infection with them. Although local infections will contribute a substantial reservoir of infection, their importance relative to an influx of immigrating infections needs to be addressed and on a regular basis as it will certainly alter over the course of the epidemic at the global and local scale.

Thus, here we address this across several countries that imposed differing levels of confinement and assess the added value of inclusion of mobility data in explaining and predicting the epidemic dynamics at the local scale.

5.1 Methods

Using data from the "Facebook data for Good" program, which provide data on all users of the application, we first assessed the impact of the lockdown strategy on mobility patterns among administrative units in four different countries: Colombia, France, US (west coast), and Sweden. These countries were chosen to cover the range of degrees of lockdowns enforced from none (Sweden), mild (US), and increasingly rigid (France and then Colombia). The administrative units in these countries are county (Sweden, US), department (France), and municipio (Colombia). We then assessed the contribution of these mobility fluxes for the diffusion of SARS-CoV-2 among administrative units of the same territories.

Case data for US, Sweden, and Colombia and positive viral tests for France at the appropriate administrative scales and dates for which Facebook data were available, were retrieved from national public health data websites. All mobility data were fully anonymized and no individually identifiable information was provided. Facebook movements from one administrative unit to another were then summed by week for every administrative unit. The number of cases in the unit of origin was then summed for the same week and multiplied by the summed Facebook movements from unit of origin to unit of destination. This thus generated a potential incoming flux of infection (FoI) for every unit of destination from every unit of origin. These values were then logarithm transformed and a statistical regression analysis (loglinear poisson regression) performed to assess the added value, on top of the case number recorded in each locality the previous week, of including such an influx on the number of cases or infections in the unit of destination the following week. In addition, because one might expect viral import to be more important at the start of the epidemic and then local case number more important once the virus was seeded in a place, we modelled the interaction between the two variables (FoI and Case number) on the number of cases the following week. The log(e) of the administrative unit was used in the analysis as an offset term. Thus the fitted regression analysis was:

$$\mathrm{Log}_e(Y)_t = \beta 0 + \beta 1.\mathrm{Cases}_{t-1} + \beta 2.\mathrm{FoI}_{t-1} + \beta 3.(\mathrm{Cases}_{t-1} \times \mathrm{FoI}_{t-1}) + \varepsilon \tag{1}$$

where Y is the number of cases, subscript t is time (here week) and FoI the incoming flux of infection.

To quantify the contributions of these variables to COVID cases we estimate the increased relative risk associated with increased FoI. Relative risk is the ratio of the probability of COVID incidence in an exposed group to the probability of incidence of COVID in an unexposed group. Here exposure and non-exposure is a continuous scale determined by incoming flux of virus to an area. Thus, more precisely we are assessing how case number is influenced by different levels of exposure as defined by the incoming flux of infection. Relative risk measures how much increased risk of COVID is associated with a unit increase in the incoming flux of infection (note that incoming flux was log transformed and thus we are assessing the increased risk associated with an increase of one log of the flux of infection). For example, a relative risk of 2 means twice the incidence rate of COVID in an area that has one log increase in the incoming flux of infection. We also calculate the percentage of variation in COVID cases explained by the variables in the regression to provide an additional measure of the contribution of each of the variables.

5.2 Results

5.2.1 Colombia

On March 6, 2020, Colombia recorded its first case in an individual who had recently returned from Italy (minsalud.gov.co). Over the next week 15 more cases were detected in several of the largest cities throughout the country and public health authorities declared a health emergency, suspending all public events involving more than 500 people (Reuters 2020a). Days later educational establishments were shut and a state of national emergency was announced. A week later, on March 24, a national lockdown was announced and this was repeatedly extended until August 1. Following lockdown, mobility, as discerned through inter-administrative unit Facebook data, initially decreased by 60–70% of pre-lockdown values before steadily rising again to only a 30% decrease by the epidemic peak (Fig. 1a). During the period March 16 until July 27, Colombia recorded 324,451 cases peaking in the week starting July 13 with 55,936 cases. The number of affected municipios (for which Facebook data were also available, that is, 816 of the total of 1123) increased gradually during the initial phases of the epidemic (March 15 until May 10) at which point the number increased more rapidly before accelerating from June 14 up to the peak in the week of July 6 (Fig. 1b). This temporally corresponds to the period when mobilities were on the increase again. The peak number of affected municipios occurred one week prior to the peak in cases the following week. The previous month case number (30–70%) explained the majority of current month's case number variation among municipios. However, the FoI initially also explained a considerable amount of unit case number (5–15%), before steadily decreasing to becoming insignificant during the middle weeks of the epidemic (May 25 to June 22), before it increased again, explaining 1–8%. This is reflected in the significant relative risk associated with this FoI at the end of the epidemic when mobility was on the increase again and the virus being increasingly spread throughout the country (Fig. 1b). In addition, there was strongly significant risk associated with the FoI at the beginning of the epidemic. Coupled with a small but statistically significant negative interaction with the local case number, this would suggest that viral import, as estimated through Facebook

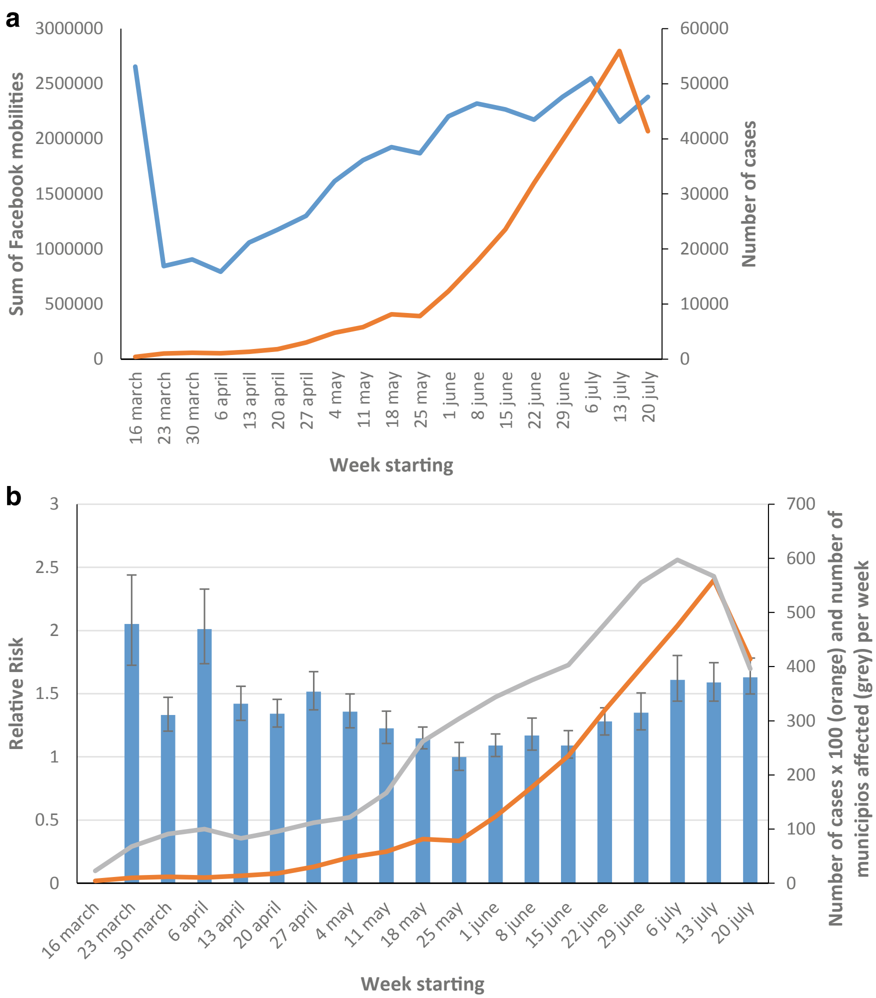

Fig. 1 **a** Total Facebook inter-municipio mobilities (blue line) and number of cases (orange line) by week in Colombia **b** Total number of weekly cases (orange line), number of municipios affected (grey line) out of the 816 municipios and the relative risk (+95% confidence intervals) associated with a log unit increase in Facebook incoming flux of infection (blue bars) in Colombia. See Sect. 5.1 Methods for details

mobility patterns, was more significant in explaining the local case number when the case number in the same municipio the previous week was small. This is thus consistent with the idea that viral spread is being captured by Facebook mobility, but once seeded the virus rapidly expands locally. Surprisingly, however, despite the virus being widely distributed in many hundreds of municipios towards the end of the epidemic, the FoI still remained an important factor. That is, viral import was still contributing a substantial fraction of the observed cases.

5.2.2 France

In France, the government imposed the first national lockdown on March 17, which lasted until May 11. The impact of lockdown on mobility was high with a 70–80% decrease over the entirety of this period (Fig. 2a). From the period of March 18 until the July 28, there were 68,652 positive tests out of over three million tests performed. The number of positive tests peaked in the week of March 25, despite the number of tests being performed increasing ten-fold from May 27. Although initially identified on French soil in Chinese tourists on January 24, retrospective testing

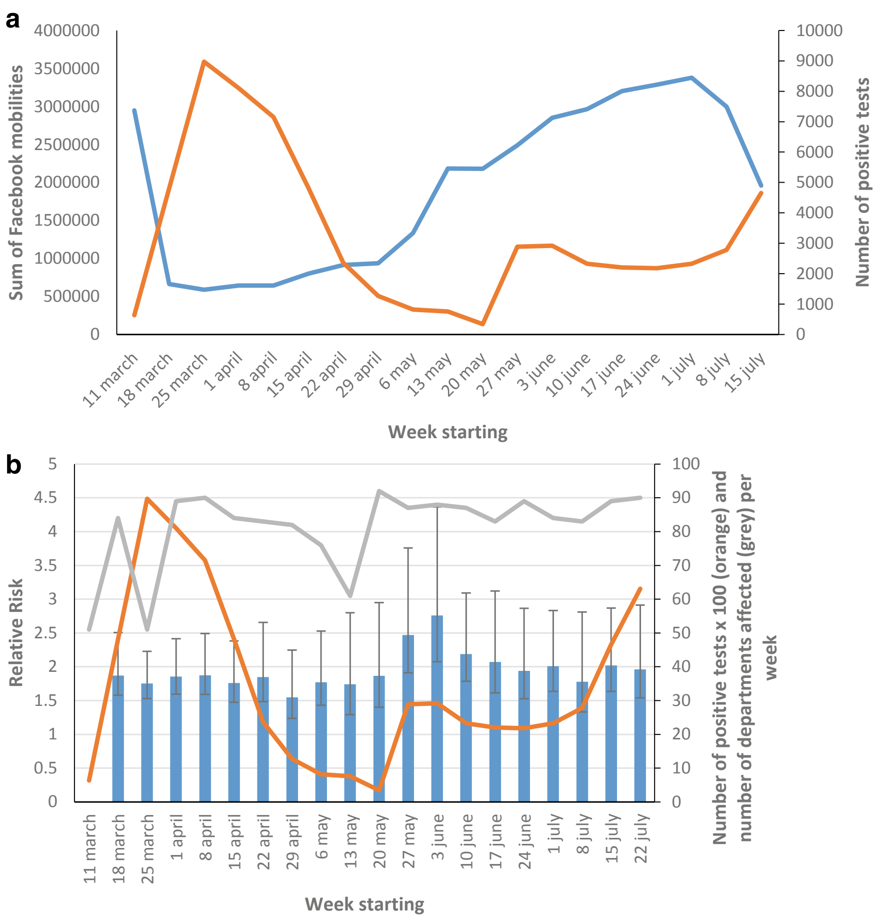

Fig. 2 **a** Total Facebook inter-department mobilities (blue line) and number of positive tests (orange line) by week in France **b** Total number of weekly positive tests ×100 (orange line), number of departments affected out of the 94 departments (grey line) and the relative risk (+95% confidence intervals) associated with a log unit increase in Facebook incoming flux of infection (blue bars) in France. See Sect. 5.1 Methods for details

of pneumonia cases found one individual positive on December 27, 2019. During February, the number of clusters of cases increased rapidly and during the first week of the lockdown 51 departments recorded positive cases despite a low level of testing. The number of departments recording positive cases every week escalated rapidly to concern almost every one of the 94 metropolitan departments by the beginning of April. The FoI explained nearly 20% of variation in positive test number in the first week of lockdown and its explanatory power decreased only very slowly during the lockdown before once again attaining 10% explanatory power post-lockdown. Thus, despite the fact that the virus was already implanted throughout the country, the FoI explained a considerable amount of variation in positive test number and irrespective of the number of tests being performed. The importance of viral import is underlined by the estimated relative risk associated with this FoI that remained significantly above 1 throughout the entire study period (Fig. 2b). Once again, there was a significant and negative interaction effect between FoI and department infection number on the number of infections in the following week. This would again suggest that although the virus was widespread, viral import was still playing a major role, especially where and when infection numbers were low.

5.2.3 US (West Coast)

In the US states of Arizona, California, Idaho, Montana, Nevada, Oregon, Utah, and Washington, from March 10 until July 21, there were over one million cases with the epidemic showing no sign of slowing down. Of the 3194 counties in these states for which Facebook data were available, cases were detected in 461 counties in the week starting March 1 before rapidly rising within a few weeks to cover over 2000 counties. This number remained relatively stable until June 1 with over 2300 counties detecting cases regularly and reached 2900 counties affected by July 14. Lockdown was a very patchy affair in the US, with local officials often delivering stay-at-home orders even prior to any individual state responses. California issued such orders state-wise before March 22, Idaho, Montana, Oregon, and Washington followed suit before March 29 and Nevada and Arizona by April 12. Utah did not order a state-wise order, but Salt Lake City, the capital, did. Patterns of mobility thus varied substantially across the region, but overall mobility initially did decrease by 30–50% of pre-lockdown values before steadily rising again to only a 30% decrease by the epidemic peak in the month of May across the whole of the region (Fig. 3a). The majority of the variation in the current month's number of cases was explained by the previous month case number (50–80%). However, again the FoI also explained a considerable amount of county case number. After initially explaining 15% of the variation, the explanatory role of the FoI dropped and stabilized at ~6% during the months of May and early June when mobility was reduced. However, as mobility increased again, so did the contribution of FoI. This reiterates the important role that mobility is playing in viral import despite the virus already circulating locally. Likewise, after an initial drop, the relative risk associated with this FoI increased again to pre-lockdown levels and more and especially so when the weekly case

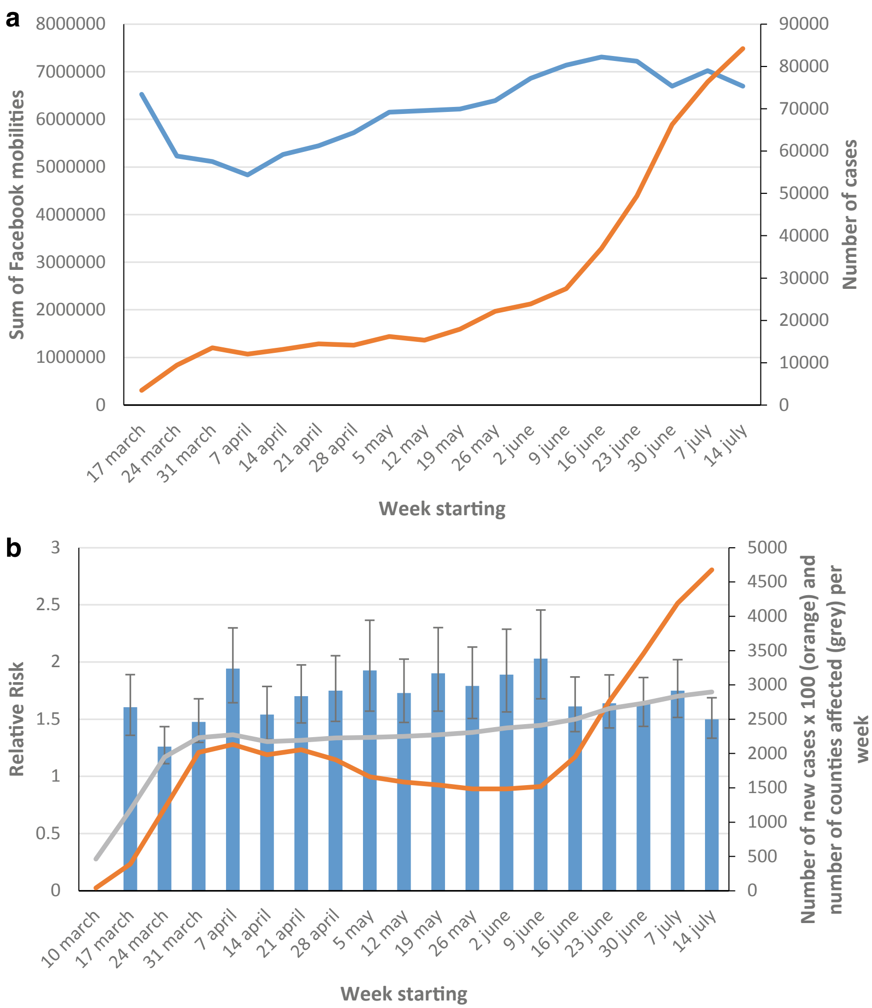

Fig. 3 **a** Total Facebook inter-county mobilities (blue line) and cases (orange line) by week in the US **b** Total number of weekly cases ×100 (orange line), number of counties affected out of the 3194 counties (grey line) and the relative risk (+95% confidence intervals) associated with a log unit increase in Facebook incoming flux of infection (blue bars) in US. See Sect. 5.1 Methods for details

number was decreasing during the mid-part of the epidemic (Fig. 3b). This, coupled with the negative interaction effect as described above, reinforces the hypothesis that the incoming virus is of most significance when the local case number is low.

5.2.4 Sweden

Sweden is a country apart where no lockdown was imposed, although higher educational establishments were shut and people encouraged, when possible, to work from home. Sweden is sub-divided into 290 municipalities, but only ten municipalities house almost 30% of the total population. The first case of COVID was detected on January 31. Subsequently, from April 13 until July 20 there were 66,184 cases of COVID. The shape of the epidemic curve in Sweden was much flatter and higher for longer than that of France, which would be expected when there was no lockdown, as can be seen from the absence of any decrease in mobilities Fig. 4a, b. Intriguingly, there was no association of FoI with case number at any time during the epidemic. In addition, there was no interaction (between weekly case number and FoI) as seen in the other three countries. By contrast, the previous week's cases explained 70–80% of all the variance, in line with findings from the other countries. The absence of any mobility associations with case number may be a consequence of the possibility that the virus was already homogeneously spread throughout the country. However, observing the incidence rate distribution across Sweden suggests this not to be the case (Fig. 5), although the high proportion of asymptomatic infections may generate a deceptive picture and age-specific hospitalization data may be more informative as to the true distribution of the virus (O'Driscoll et al. 2020). Interestingly, a serological survey carried out at the end of April found that only 7% of the population carried antibodies, a number similar to that estimated elsewhere (Reuters 2020b; Salje et al. 2020). Achieving such low levels of contamination without lockdown has been suggested to reflect a natural tendency in Swedes to reduce social contacts despite no imposed regulations, akin to observed behavioural changes in Tokyo (Yabe et al. 2020). While this would contribute to local viral transmission, there was no noticeable change in Facebook mobility at the inter-municipality level suggesting no significant reduction in population movements at this scale.

5.3 Discussion

Across three of the four study countries there was a significant relative risk associated with population mobility, despite quite different degrees of confinement. In all cases, this mobility associated risk remained relatively stable over time. Only in Colombia was there some evidence after more than two months of lockdown that mobility patterns no longer contributed to increased risk of case number. Although not directly comparable, because of differing case definitions, the stability and similarity of the relative risk over time within US and France, with intermediate vs. high levels of lockdown, would suggest that a mass quarantine strategy has to be very rigorously applied for it to work. A priori, brute comparison of countries with very different societal structures and pre-COVID mobility patterns would not be expected to generate such similar findings. Pre-COVID mobility patterns were highly concentrated in administrative units neighbouring the large cities. This was especially the

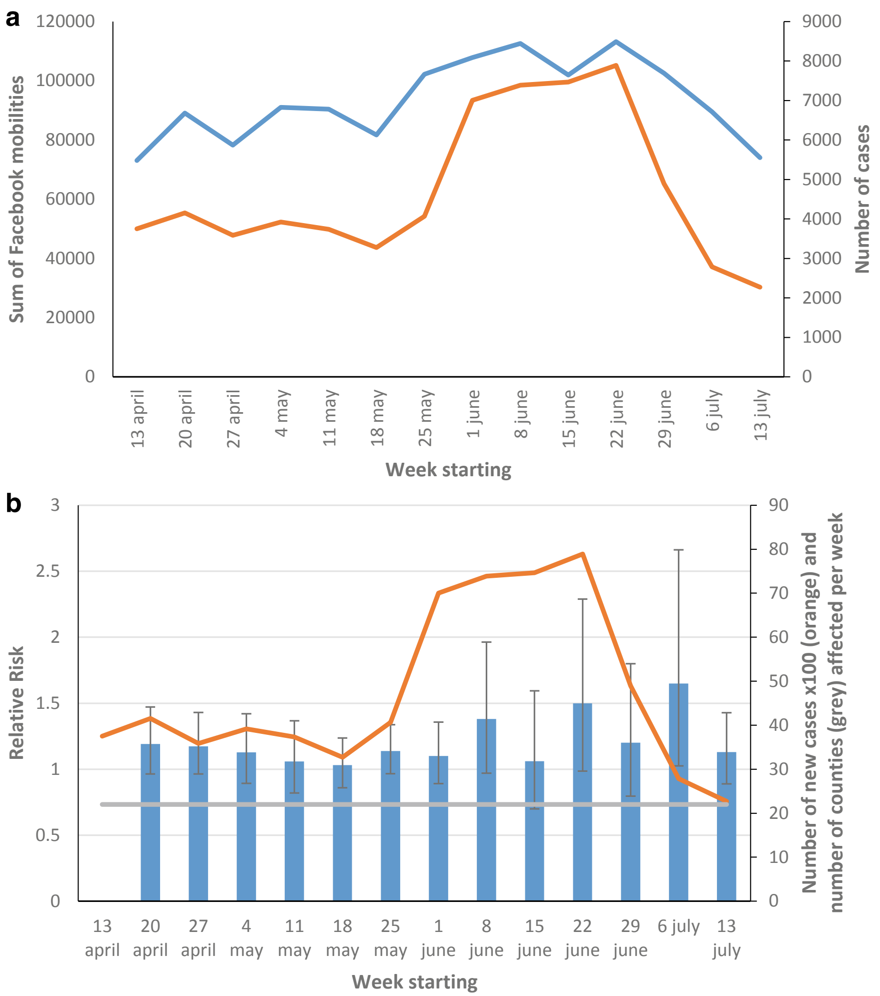

Fig. 4 **a** Total Facebook inter-county mobilities (blue line) and cases (orange line) by week in Sweden **b** Total number of weekly cases ×100 (orange line), number of counties affected out of the 22 counties (grey line) and the relative risk (+95% confidence intervals) associated with a log unit increase in Facebook incoming flux of infection (blue bars) in Sweden. See Sect. 5.1 Methods for details

case for Colombia. Upon lockdown in France, US, and Colombia, the largest proportion of the decrease in mobilities occurred at longer geographical scales, while local movement among neighbouring units decreased far less. Such local-scale movement would thus generate a forest fire type signature of viral seeding and expansion among neighbours. Secondly, measuring overall reductions in mobility belies the true nature of the change in population mobility. It is likely that a disproportionate number of individuals who maintained their mobility patterns among neighbouring

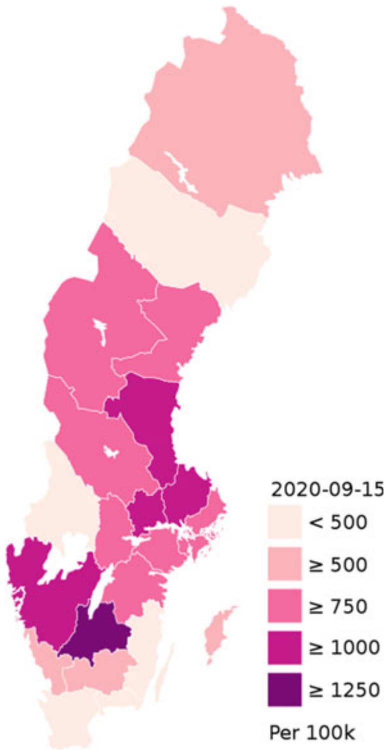

Fig. 5 Covid-19 incidence rate per 100,000 individuals per county in Sweden. *Source* https://fr.wikipedia.org/wiki/Pand%C3%A9mie_de_Covid-19_en_Su%C3%A8de#cite_note-FHM_Official_stats-1

units would be those actively involved in commercial activities and having a higher average number of contacts per person than the general population. Thus, although not being superspreaders per se, such individuals would create the opportunity for viral spread. This then begs the question of the utility of imposing lockdown on the general population when the vast majority, if using local social distancing measures, would have few contacts and contribute little to viral spread.

There are clear limitations to the utility of Facebook data and inter-country comparisons. Facebook users may not be representative of the general population. Children and the elderly use Facebook less but are more likely to have a reduced mobility at all times. The adult working population are thus more likely to be Facebook users and more likely to travel at all times, including being part of the essential workers and therefore permitted to travel during lockdown. In so far as the epidemiological role of children is now believed to be less than that of adults (Li et al. 2020b), the Facebook data may actually give a more representative picture of the flow of the important epidemiological sector of the population. Secondly, different countries use Facebook to varying extents. Rough estimates simply based on the total number of inter-administrative unit mobilities pre-lockdown divided by the total population generate values of 1 in 7 for the US, 1 in 20 for France, 1 in 100 for Sweden, and 1 in 1000 for Colombia. This reflects many differences of the countries, including not only actual Facebook use but also how the society is structured. For Colombia and Sweden, for example, most activity is always focussed at a very local scale, directly around the cities. This is less the case in the US and France. However, this being said, it is remarkable that such a simple measure of mobility yields consistent results with respect to risk attributed to mobility across three very different settings. Case and/or infection data will always be subject to uncertainty, even within the same country because of changes in case definitions and extent of testing. While such under- or mis-reporting would impact upon the total number of cases/infections, over time within France, US, and Colombia, there was relative stability in the contribution of mobility for local case count despite increased overall incidence rate; this would suggest that mis-reporting is not a significant issue.

6 Incorporating Mobilities for Public Health Preparedness and Response

In contrast to the first wave, European governments have now implemented less draconian measures with classification of administrative regions (for example departments in France and boroughs in the UK) into levels or tiers of vulnerability. These tiers are based on epidemiological indicators, including overall incidence rates, case counts specifically in the elderly population, hospital bed and Intensive care unit occupation, and predicted increase/decrease of the epidemic curve. The epidemiological models currently used for predicting how incidence rate and the other indicators will evolve are based on classical models for respiratory viruses largely developed for influenza and fine-tuned during the first wave of the pandemic. While generally successful in estimating the dynamics of the epidemic, ignoring the importance of inter-regional population flux will lead to poor predictive power in the short term. This in turn will lead to administrative units rapidly having to alter their severity level, thereby unnecessarily creating confusion and potential societal unrest. In light of our findings that incorporating mobility improves significantly the statistical model fit, its inclusion in predictive models is warranted. One way of approaching this is through a metapopulation approach.

Metapopulation theory considers populations as patches of populations that are loosely connected through migrational events, where populations are locally governed by intrinsic population dynamics but which are globally connected. At the metapopulation scale, local patches are colonized at a rate governed by immigration of the invasive organism, but which then may become extinct locally. Metapopulation approaches, originally developed for ecological systems, have been applied to infectious diseases (Grenfell and Harwood 1997; Teissier et al. 2020). A key feature of the metapopulation approach is that while local populations of hosts and pathogens may be unstable, with for example local extinction, loosely connected populations, at whatever scale, may enable pathogen survival at the global scale. Theoretical work, to some extent supported by empirical data, has highlighted several key requisites for a metapopulation approach to be useful: notably a small (ish) R_0 and a short period of infectiousness. SARS-CoV-2 fulfils these two criteria. During the epidemic phase within a local population, the incidence rate will be largely governed by deterministic dynamics that can be estimated using classical susceptible-infectious-resistant (SIR) models and the influence of the metapopulation is small. Subsequently, there will be a density-dependent deceleration in the number of new cases and eventually a decline, which may or may not lead to local pathogen extinction. Persistence of the pathogen will be strongly affected by stochastic factors, notably the number of susceptible hosts, as well as the connectedness to other populations and the consequent influx of new pathogens. Metapopulation models explicitly take into account space, allowing for the investigation of the effect that spatial heterogeneity, such as environmental stochasticity and change, has on the dynamics of the system. Recent investigations on social complex networks indicate that physical distances do not always map well onto the actual contacts among individuals and distant populations can exhibit stronger interactions than expected. Therefore, complementary to deterministic modelling approaches and with the recognition of the importance of spatial structure in viral transmission, metapopulation models (of coupled SIRs) offer a highly appropriate method to model SARS-CoV-2 dynamics at a country scale. Thanks to the real-time availability of Facebook and potentially other social media data, such modelling can be performed in real time. Perhaps more importantly, because we now have accumulated data from the start of the epidemic, we have gained knowledge as to how mobilities actually change under specific conditions and thus these fluxes can be used predictively.

7 Concluding Remarks

The increasing amount of mobile phone and social media data is providing us with an ever more detailed description of human mobilities. Incorporating such information into models of infectious diseases will vastly improve our capacity to identify sources and pathways of the spread of infection. This in turn will enable a much more targeted approach for implementing meso-scale interventions without the need to impose blanket lockdowns. Although perhaps too late for the current pandemic, generating nationwide matrices describing mobility patterns will serve as frameworks within which the spread of other pathogens can be addressed, enabling predictability for preparedness and intervention.

References

Al Wahaibi A, Al Manji A, Al Maani A et al (2020) COVID-19 epidemic monitoring after non-pharmaceutical interventions: the use of time-varying reproduction number in a country with a large migrant population. Int J Infect Dis 99:466–472. https://doi.org/10.1016/j.ijid.2020.08.039

Anderson RM, Heesterbeek H, Klinkenberg D, Hollingsworth TD (2020) How will country-based mitigation measures influence the course of the COVID-19 epidemic? Lancet 395:931–934

Backer JA, Klinkenberg D, Wallinga J (2020) Incubation period of 2019 novel coronavirus (2019-nCoV) infections among travellers from Wuhan, China, 20–28 January 2020. Euro Surveill 25:2000062

Bengtsson L, Gaudart J, Lu X et al (2015) Using mobile phone data to predict the spatial spread of cholera. Sci Rep 5:8923

Benkimoun S, Denis E, Chalonge L, Telle O, Paul R (2020) Évolution des mobilités et diffusion du Covid-19 en France: ce que les données Facebook dévoilent. The Conversation, May 22, 2020. https://theconversation.com/evolution-des-mobilites-et-diffusion-du-covid-19-en-france-ce-que-les-donnees-facebook-devoilent-137846

Buckee CO, Balsari S, Chan J et al (2020) Aggregated mobility data could help fight COVID-19. Science 368:145–146

Buitrago-Garcia D, Egli-Gany D, Counotte MJ et al (2020) Occurrence and transmission potential of asymptomatic and presymptomatic SARS-CoV-2 infections: a living systematic review and meta-analysis. PLoS Med 17(9):e1003346. https://doi.org/10.1371/journal.pmed.1003346

Chidambaram S, Erridge S, Kinross J, Purkayastha S, Collaborative PanSurg (2020) Observational study of UK mobile health apps for COVID-19. Lancet Digit Health 2(8):e388–e390. https://doi.org/10.1016/S2589-7500(20)30144-8

Chinazzi M, Davis JT, Ajelli M et al (2020) The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. Science 368(6489):395–400. https://doi.org/10.1126/science.aba9757 PMID:32144116;PMCID:PMC7164386

Dropkin G (2020) COVID-19 UK lockdown forecasts and R0. Frontiers in Public Health, 8256. www.frontiersin.org/article/10.3389/fpubh.2020.00256. https://doi.org/10.3389/fpubh.2020.00256

Endo A, Abbott S, Kucharski AJ, Funk S (2020) Estimating the overdispersion in COVID-19 transmission using outbreak sizes outside China. Wellcome Open Research 5:67 https://doi.org/10.12688/wellcomeopenres.15842.3

European Centre for Disease Prevention and Control (ECDC) (2020a) Rapid Risk Assessment: Coronavirus disease 2019 (COVID-19) in the EU/EEA and the UK—eleventh update: resurgence of cases. Stockholm: ECDC. www.ecdc.europa.eu/en/publications-data/rapid-risk-assessment-coronavirus-disease-2019-covid-19-eueea-and-uk-eleventh

European Centre for Disease Prevention and Control (ECDC) (2020b) Strategies for the surveillance of COVID-19. Stockholm: ECDC. www.ecdc.europa.eu/en/publications-data/strategies-surveillance-covid-19

European Centre for Disease Prevention and Control (ECDC) (2020c) Case definition for coronavirus disease 2019 (COVID-19). Stockholm: ECDC. www.ecdc.europa.eu/en/covid-19/surveillance/case-definition

European Centre for Disease Prevention and Control (ECDC) (2020d) Surveillance of COVID-19 at long-term care facilities in the EU/EEA. Stockholm: ECDC. www.ecdc.europa.eu/en/publications-data/surveillance-COVID-19-long-term-care-facilities-EU-EEA

eHealth Network, Mobile applications to support contact tracing in the EU's fight against COVID-19: Common EU Toolbox for Member States (2020) https://ec.europa.eu/health/sites/health/files/ehealth/docs/covid-19_apps_en.pdf

European Commission (2020) Joint European roadmap towards lifting COVID-19 containment measures. https://ec.europa.eu/info/sites/info/files/communication_-_a_european_roadmap_to_lifting_coronavirus_containment_measures_0.pdf

Ferguson NM, Laydon D, Nedjati-Gilani G et al (2020) Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand. https://dsprdpub.cc.ic.ac.uk:8443/handle/10044/1/77482

Finger F, Genolet T, Mari L et al (2016) Mobile phone data highlights the role of mass gatherings in the spreading of cholera outbreaks. Proc Natl Acad Sci USA 113:6421–6426

Fisher D, Wilder-Smith A (2020) The global community needs to swiftly ramp up the response to contain COVID-19. Lancet 395:1109–1110

Flaxman S, Mishra S, Gandy A et al (2020) Estimating the number of infections and the impact of non-pharmaceutical interventions on COVID-19 in 11 European countries. Imperial College London (30–03–2020). https://doi.org/10.25561/77731

Gates B (2020) Responding to Covid-19-a once-in-a-century pandemic? N Engl J Med 382:1677–1679

Ghinai I (2020) Community transmission of SARS-CoV-2 at two family gatherings—Chicago, Illinois, February–March 2020. MMWR Morb Mortal Wkly Rep 69:446–450

Gibbs H, Liu Y, Pearson CAB et al (2020) Changing travel patterns in China during the early stages of the COVID-19 pandemic. Nat Commun 11(1):5012. https://doi.org/10.1038/s41467-020-18783-0 PMID:33024096;PMCID:PMC7538915

Grantz KH, Meredith HR, Cummings DAT et al (2020) The use of mobile phone data to inform analysis of COVID-19 pandemic epidemiology. Nat Commun 11(1):4961. https://doi.org/10.1038/s41467-020-18190-5 PMID:32999287;PMCID:PMC7528106

Grenfell B, Harwood J (1997) (Meta)population dynamics of infectious diseases. Trends Ecol Evol., Oct., 12(10), 395–399.

Hamner L (2020) High SARS-CoV-2 attack rate following exposure at a choir practice—Skagit County, Washington, March 2020. MMWR Morb Mortal Wkly Rep 69:606–610

Iacobucci G (2020) Covid-19: mass population testing is rolled out in Liverpool. BMJ 371:m4268. https://doi.org/10.1136/bmj.m4268

Jarvis CI, Van Zandvoort K, Gimma A et al (2020) Quantifying the impact of physical distance measures on the transmission of COVID-19 in the UK. BMC Med 18(1):124. https://doi.org/10.1186/s12916-020-01597-8 PMID:32375776;PMCID:PMC7202922

Kraemer MUG, Yang CH, Gutierrez B et al (2020) The effect of human mobility and control measures on the COVID-19 epidemic in China. medRxiv [Preprint]. 6:2020.03.02.20026708. doi: https://doi.org/10.1101/2020.03.02.20026708. Update in: Science, 368(6490), 493–497. PMID: 32511452; PMCID: PMC7239080.

Kucharski AJ, Klepac P, Conlan AJK et al (2020) Effectiveness of isolation, testing, contact tracing, and physical distancing on reducing transmission of SARS-CoV-2 in different settings: a mathematical modelling study. Lancet Infect Dis 20(10):1151–1160. https://doi.org/10.1016/S1473-3099(20)30457-6 PMID: 32559451

Lai S, Ruktanonchai NW, Zhou L et al (2020) Effect of non-pharmaceutical interventions to contain COVID-19 in China. Nature. In press https://doi.org/10.1038/s41586-020-2293-x

Lau MSY, Grenfell B, Thomas M, Bryan M, Nelson K, Lopman B (2020) Characterizing superspreading events and age-specific infectiousness of SARS-CoV-2 transmission in Georgia, USA. Proc Natl Acad Sci USA 117(36):22430–22435. https://doi.org/10.1073/pnas.2011802117 PMID:32820074;PMCID:PMC7486752

Lauer SA, Grantz KH, Bi Q et al (2020) The incubation period of coronavirus disease 2019 (COVID-19) from publicly reported confirmed cases: estimation and application. Ann Intern Med 172:577–582

Laxminarayan R, Wahl B, Dudala SR et al (2020) Epidemiology and transmission dynamics of COVID-19 in two Indian states. Science. https://doi.org/10.1126/science.abd7672

Leclerc QJ, Fuller NM, Knight LE et al (2020) What settings have been linked to SARS-CoV-2 transmission clusters? Wellcome Open Res 5:83 https://doi.org/10.12688/wellcomeopenres.15889.2

Li Q, Guan X, Wu P et al (2020) Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. N Engl J Med 382:1199–1207

Li X, Xu W, Dozier M et al (2020) The role of children in transmission of SARS-CoV-2: A rapid review. J Glob Health 10(1):011101. https://doi.org/10.7189/jogh.10.011101

Lloyd-Smith JO, Schreiber SJ, Kopp PE, Getz WM (2005) Superspreading and the effect of individual variation on disease emergence. Nature 438:355–359. https://doi.org/10.1038/nature04153

McKee M, Stuckler D (2020) If the world fails to protect the economy, COVID-19 will damage health not just now but also in the future. Nat Med 26:640–642. https://doi.org/10.1038/s41591-020-0863-y

minsalud.gov.co (2020) Colombia confirma su primer caso de COVID-19. www.minsalud.gov.co/Paginas/Colombia-confirma-su-primer-caso-de-COVID-19.aspx

O'Driscoll M, Dos Santos GR, Wang L et al (2020) Age-specific mortality and immunity patterns of SARS-CoV-2. Nature. https://doi.org/10.1038/s41586-020-2918-0

Peak CM, Wesolowski A, Zu Erbach-Schoenberg E et al (2018) Population mobility reductions associated with travel restrictions during the Ebola epidemic in Sierra Leone: use of mobile phone data. Int J Epidemiol 47(5):1562–1570. https://doi.org/10.1093/ije/dyy095 PMID:29947788;PMCID:PMC6208277

Peak CM, Kahn R, Grad YH et al (2020) Individual quarantine versus active monitoring of contacts for the mitigation of COVID-19: a modelling study. Lancet Infect Dis 20(9):1025–1033. https://doi.org/10.1016/S1473-3099(20)30361-3 PMID:32445710;PMCID:PMC7239635

Petersen E, Koopmans M, Go U et al (2020) comparing SARS-CoV-2 with SARS-CoV and influenza pandemics. Lancet Infect Dis 20(9):e238–e244. https://doi.org/10.1016/S1473-3099(20)30484-9

Pollina E, Busvine D (2020) European mobile operators share data for coronavirus fight. Reuters. March 18. www.reuters.com/article/us-health-coronavirus-europe-telecoms-idUSKBN2152C2

Porter D (1998) Health, civilization and the state: a history of public health from ancient to modern times. Routledge, New York, p 388

Pullano G, Valdano E, Scarpa N, Rubrichi S, Colizza V (2020) Evaluating the effect of demographic factors, socioeconomic factors, and risk aversion on mobility during the COVID-19 epidemic in France under lockdown: a population-based study. Lancet Digit Health 2(12):e638–e649. https://doi.org/10.1016/S2589-7500(20)30243-0 PMID:33163951;PMCID:PMC7598368

Remuzzi A, Remuzzi G (2020) COVID-19 and Italy: what next? Lancet 395(10231):1225–1228. https://doi.org/10.1016/S0140-6736(20)30627-9 PMID:32178769;PMCID:PMC7102589

Reuters (2020a) Colombia declares health emergency to tackle coronavirus. www.reuters.com/article/us-health-coronavirus-colombia/colombia-declares-health-emergency-to-tackle-coronavirus-idUSKBN20Z2QX

Reuters (2020b) www.reuters.com/article/us-health-coronavirus-sweden-strategy/swedish-antibody-study-shows-long-road-to-immunity-as-covid-19-toll-mounts-idUKKBN22W2YC

Rocklöv J, Sjödin H, Wilder-Smith A (2020) COVID-19 outbreak on the Diamond Princess cruise ship: estimating the epidemic potential and effectiveness of public health countermeasures. J Travel Med https://pubmed.ncbi.nlm.nih.gov/32109273/

Romm T, Dwoskin E, Timberg C (2020) U.S. government, tech industry discussing ways to use smartphone location data to combat coronavirus. Washington Post. March 18. www.washingtonpost.com/technology/2020/03/17/white-house-location-data-coronavirus/

Salje H, Tran Kiem C, Lefrancq N et al (2020) Estimating the burden of SARS-CoV-2 in France. Science 369(6500):208–211. https://doi.org/10.1126/science.abc3517

Sanche S, Lin Y, Xu C, Romero-Severson E, Hengartner N, Ke R (2020) High contagiousness and rapid spread of severe acute respiratory syndrome coronavirus 2. Emerg Infect Dis 26(7):1470–1477. https://doi.org/10.3201/eid2607.200282

Sehdev PS (2002) The origin of quarantine. Clin Infect Dis 35(9):1071–1072. https://doi.org/10.1086/344062

Teissier Y, Paul R, Aubry M et al (2020) Long-term persistence of monotypic dengue transmission in small size isolated populations, French Polynesia, 1978–2014. PLoS Negl Trop Dis 6, 14(3):e0008110. https://doi.org/10.1371/journal.pntd.0008110. PMID: 32142511

Telle O, Benkimoun S, Paul R (2021) The effect of mobility restrictions on the SARS-CoV-2 diffusion during the first wave: what are the impacts in Sweden, USA, France and Colombia. MEDRXIV/2021/250935

Wesolowski A, Eagle N, Tatem AJ et al (2012) Quantifying the impact of human mobility on malaria. Science 338(6104):267–270. https://doi.org/10.1126/science.1223467 PMID:23066082;PMCID:PMC3675794

Wesolowski A, Qureshi T, Boni MF et al (2015) Impact of human mobility on the emergence of dengue epidemics in Pakistan. Proc Natl Acad Sci USA 112(38):11887–11892. https://doi.org/10.1073/pnas.1504964112 PMID:26351662;PMCID:PMC4586847

Wesolowski A, Buckee CO, Engø-Monsen K, Metcalf CJE (2016) Connecting mobility to infectious diseases: the promise and limits of mobile phone data. J Infect Dis 214:S414–S420

Wesolowski A, Winter A, Tatem AJ et al (2018) Measles outbreak risk in Pakistan: exploring the potential of combining vaccination coverage and incidence data with novel data-streams to strengthen control. Epidemiol Infect 146(12):1575–1583. https://doi.org/10.1017/S0950268818001449 PMID:29860954;PMCID:PMC6090714

WHO (2003) Consensus document on the epidemiology of severe acute respiratory syndrome (SARS). www.who.int/csr/sars/WHOconsensus.pdf?ua=1. Accessed November 4, 2020.

WHO (2019) Middle East respiratory syndrome coronavirus (MERS-CoV). www.who.int/en/news-room/fact-sheets/detail/middle-east-respiratory-syndrome-coronavirus-(mers-cov). Accessed November 4, 2020.

WHO (2020a) Report of the WHO–China joint mission on coronavirus disease 2019 (COVID-19). Feb 16–24, 2020. www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf. Accessed November 5, 2020.

WHO (2020b) Coronavirus disease 2019 (COVID-19) Situation Report –94. https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200423-sitrep-94-covid-19.pdf. Accessed November 4, 2020.

Wu JT, Leung K, Leung GM (2020) Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study. Lancet 395:689–697

Yabe T, Tsubouchi K, Fujiwara N et al (2020) Non-compulsory measures sufficiently reduced human mobility in Tokyo during the COVID-19 epidemic. Sci Rep 10:18053. https://doi.org/10.1038/s41598-020-75033-5

Yu IT, Li Y, Wong TW, Tam W et al (2004) Evidence of airborne transmission of the severe acute respiratory syndrome virus. N Engl J Med 350(17):1731–1739. https://doi.org/10.1056/NEJMoa032867

Zhou P, Yang XL, Wang XG et al (2020) A pneumonia outbreak associated with a new coronavirus of probable bat origin. Nature 579:270–273

Zhu N, Zhang D, Wang W et al (2020) A novel coronavirus from patients with pneumonia in China, 2019. N Engl J Med 382:727–733

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Chapter 4
Rethinking the Infodemic: Social Media and Offline Action in the COVID-19 Pandemic

Leonardo W. Heyerdahl, Benedetta Lana, and Tamara Giles-Vernick

Abstract In parallel with the COVID-19 pandemic, an infodemic—an information epidemic—challenges human populations across the planet. Often framed as an enemy to be conquered, infodemics endanger public health because inaccurate or erroneous information spreads quickly on a large scale, triggers potentially harmful behaviours, and generates stress and anxiety. Much infodemics research privileges the investigation of online information creation and circulation, as well as measures to counter erroneous information. Less examined, however, are the offline effects of an infodemic. This chapter surveys how infodemic analysts have evaluated interactions between online information and offline practice. It examines studies focusing on the harmful content of the online informational ecosystem and containment efforts, and then explores social sciences contributions, which broadly identify factors contributing to public interpretation and offline practices. We conclude with a concrete example of an anthropological study exploring the interplay of online information and offline practice during the COVID-19 pandemic.

Keywords Infodemic · COVID-19 · Social media · Red Cross

1 Introduction

In parallel with the COVID-19 pandemic, an *infodemic*—an information epidemic—challenges human populations across the planet. Characterized as "excessive" and rapidly. disseminating information that unintentionally or intentionally misleads the public about diverse aspects of the pandemic (Ratzan et al. 2020; Sharma et al. 2020), the infodemic is often framed as an enemy to be conquered. It endangers public health because inaccurate or erroneous information spreads quickly on a large scale, triggers potentially harmful behaviours, and generates profound stress and anxiety. From 2020, this infodemic appears to have catalyzed distrust and denial of COVID-19, uses of dangerous or ineffective remedies, and the destruction of telecommunications

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towers based on claims linking 5G networks with viral transmission (Biasio et al. 2020; Dubey et al. 2020; Gallotti et al. 2020; Naeem et al. 2020). Little wonder, then, that WHO Director-General Tedros Adhanom Ghebreyesus said of the COVID-19 pandemic: "We're not just fighting an epidemic; we're fighting an infodemic. Fake news spreads faster and more easily than this virus and is just as dangerous" (Zarocostas 2020).

Infodemics are complex phenomena, emerging in part from online information that is disseminated through diverse media available to publics, and from the interconnectedness and deregulation of the world wide web. Social media platforms and their public data offer useful and illuminating opportunities for studying informational dynamics on a large scale (Ceron et al. 2014; Greco and Polli 2019; Pelagalli et al. 2017). This opportunity, then, has led many infodemics researchers to privilege investigating online information creation, circulation, and change. Less examined, however, are the offline effects of an infodemic. Specifically, in focusing on online informational dynamics, infodemics specialists have attended far less to how lay publics interpret excessive, rapidly circulating information, how they make decisions about that information, and how their decisions translate into harmful behaviours. Indeed, as anthropologist Meg Stalcup has observed about the Zika infodemic in Brazil, it is frequently assumed that "what happens on social media ramifies in actions and feelings" (Stalcup 2020 p.10), without careful attention to the processes by which this takes place.

In this chapter, we survey how infodemic analysts have evaluated interactions between online information and offline practice. We begin by examining investigations that focus on the harmful content of the online informational ecosystem and containment efforts. We then examine the social sciences contributions, which broadly identify factors contributing to public interpretations and their offline practices. We conclude with a concrete example of an anthropological study exploring the interplay of online information and offline practice during the COVID-19 pandemic.

2 Rumours, Fake News, Conspiracy Theories, and Other Online Content

Infodemiology, "the science of distribution and determinants of information in an electronic medium, specifically the Internet, or in a population, with the ultimate aim to inform public health and public policy", principally analyzes and ultimately seeks to manage online content. Emerging in the early 2000s as a multidisciplinary field, infodemiology developed rapidly over the following two decades, evaluating rapidly circulating information so as to facilitate effective public health management of online information (Eysenbach 2002, 2009). Infodemiology studies, for instance, have tracked rumours and fake news during the first SARS outbreak and the Ebola and Zika epidemics (Anwar et al. 2020; Safarnejad et al. 2020; Stalcup 2020).

A second branch of investigation, infoveillance, monitors health-related information that is promulgated by mass and social media, and it highlights distinctions between misinformation (misleading information, but not deliberately designed to manipulate) and disinformation (information deliberately developed or spread to manipulate users) Confronted with expanding "fake news", public health specialists have employed infoveillance investigations to understand better the place of readers and users in spreading information (Bunker 2020; Gallotti et al. 2020; Pulido et al. 2020); to trace the activities of social media companies, TV channels, newspapers and public authorities in regulating the information arena (Donovan 2020; Mackey et al. 2020; Naeem et al. 2020); and to evaluate the impact and diffusion of specific information (Islam et al. 2020; Rovetta and Bhagavathula 2020).

In parallel with this expansion of infoveillance to monitor and regulate media platform content, risk communication studies have developed guidelines and communications techniques for actors to convey official messages. Their techniques range from limiting the negative effects of pre-prints, preliminary observations, and other unreviewed information (Casigliani et al. 2020), to calling for more responsible, scientifically-grounded, journalism (Anwar et al. 2020), to designing appealing social media posts that relay information and attract the readers' attentions (King and Lazard 2020).

These infodemic and infoveillance studies all address the supply of information, in that they focus first on information quality (evidence-based, derived from reliable sources) to achieve effective public health management and, second, on containing misinformation or disinformation. At times, supply-oriented management can involve the deletion of reports, claims, or advice designated as misinformation or misinformation. In the past year, two infodemic management frameworks, one by the World Health Organization and a second from infodemiology field founder Gunther Eysenbach, have integrated both dimensions of information quality and mis/disinformation containment (Eysenbach 2020; Tangcharoensathien et al. 2020). The underlying assumption of these reports is that online users, provided with appropriate content, would be well-informed and thus would comply with correct guidelines and measures relating to COVID-19.

Moreover, these frameworks are anchored by a further assumption about official, authoritative messages to be communicated to lay publics: that alternative messages challenge this authority. Infodemics thus constitute a security issue and must be controlled. Yet at the heart of this assumption is a fundamental problem. In a pandemic caused by a new and rapidly changing pathogen, where scientific and public health knowledge are rapidly changing, what is "true" or "false"? Is it possible to delineate clearly what types of knowledge should be monitored, controlled or censored? (Marin 2020; Southwell et al. 2019).

In contrast to these supply-oriented approaches that would channel accurate information to users, demand-oriented approaches seek to educate users in health literacy so that they can distinguish between "good" and "bad" information. Over the past decade, health literacy studies have sought to cultivate in diverse populations the capacity to search, select, and appraise health-related information and thus to enhance certain health behaviours (Britt et al. 2017; Lee et al. 2020). COVID-19 health literacy studies, for instance, have assessed readers' and users' skills in performing effective searches, understanding information, and adopting health behaviours conducive to good health; they have also recommended strategies to educate publics to select critically and to interpret health advice and information (in the COVID-19 context see, e.g.: Biasio et al. 2020; Okan et al. 2020; Rosário et al. 2020; Sentell et al. 2020). Although the health literacy approach has had its sceptics (Brown et al. 2012; Neter and Brainin 2019), this approach has catalyzed a host of "demand-side" strategies to educate lay publics. Emerging from decades-old social psychological "inoculation theory" (Compton 2013; McGuire 1964), "debunking" demonstrates that specific information is false; "social inoculation", also referred to as "pre-bunking", anticipates misinformation and disinformation by exposing users to weak, deconstructed forms of misinformation, to arm users with the critical skills to identify appropriate information and detect manipulation attempts or gaps in logic. (Compton et al. 2016; Cook et al. 2017; Lewandowsky and Van Der Linden 2021).

These infodemics approaches make important contributions to analyses of information flows and to the design of frameworks for public health management during public health emergencies. But they assume that the quality of information and public awareness of the processes that produce this information determine human behaviours. Insights from other social sciences disciplines, including psychology, anthropology, and history, suggest that complex, interacting factors shape what people believe and do in practice.

3 How Does an Information Ecosystem Affect Human Practice?

Efforts to characterize and evaluate the influence that an information ecosystem has on how certain populations feel, think, and act, remain relatively less studied than information ecosystems themselves. Nonetheless, behavioural investigations have figured prominently here, prior to and during the COVID-19 pandemic.

Drawing from psychology, behavioral studies assess the information ecosystem's effects on human psychological states, to illuminate emotional responses to infodemics and to link these responses to specific types of media used (Centola 2010; Doornwaard et al. 2015; Marino et al. 2018; Martínez-Ferrer et al. 2018; Moreno and Whitehill 2014; Saran et al. 2018; Tran et al. 2017). More recently in the COVID-19 pandemic, Luo et al. (2020) and Bala et al. (2021) have evaluated the effects of social media exposure on preventive and health behaviours through cross-sectional surveys, concluding that social media platforms offer important health guidance for lay publics, but that information overload can lead to stress and "cyberchondria" (distress caused by excessive consultation of online sites). Another investigation analyzed rumours, stigma, and conspiracy theories related to COVID-19 and accounts of the real-life effects of online news reporting, finding a correlation between infodemics and violence (Islam et al. 2020). Using social listening of Twitter and call logs of a US regional poison control centre, Chary and colleagues linked online advice of using bleach as COVID-19 prophylaxis and emergency phone calls for bleach poisoning (Chary et al. 2020).

Although such studies usefully identify psychological effects of online sources and posit compelling correlations with offline behaviour, they leave certain questions unanswered. We have no insight into how actors obtained and interpreted the specific online narratives, nor how they acted on that information. Nor do they address the socio-political logics that may influence a user's choice of information sources or the reasons that the user might seize upon certain misinformation. In addition, because these studies categorize information as true or false, they do not grasp the volatility of medical claims to truth in a pandemic. Knowledge can change rapidly during a pandemic, and as Eysenbach has argued, we are often working with best available evidence rather than stable medical facts (Eysenbach 2020).

Other social scientists have sought to excavate these concerns. Anthropologists and historians take seriously "rumours", considering them to be "more than simply stories which are not true" (Kaler 2009). The term "rumour" itself can be problematic, potentially mobilized by authorities to dismiss stories that they found destabilizing (Geissler and Pool 2006). Yet the contributions of these scholars has been important: they have been less preoccupied by the veracity of claims than in using the claims to better understand specific social groups' perceptions, values, and worldviews (Ceyssens 1975; Fairhead et al. 2006; Geissler and Pool 2006; Graboyes 2015; Kaler 2004, 2009; Scheper-Hughes 2001; Tappan 2014; White 2000). From rumours of blood theft to those of sterility, these stories offer insight into distrust and critique of biomedical research, as well as broader reflections on the plural inequalities inherited from the colonial period. More broadly, field-based qualitative social sciences like anthropology and history situate a social group's specific understandings and practices within their broader socio-cultural, political, and economic contexts (Geissler and Pool 2005).

Although none of the foregoing studies addresses how online claims shape human offline practices, this anthropological insistence of evaluating all online claims, regardless of their veracity, to illuminate how people gather, interpret, and act on such claims have made their way into infodemics research, including that related to the COVID-19 pandemic (Durand and Cunha 2020; Kozinets 2015; Krieg et al. 2017; Larson 2020; Stalcup 2020). In our research in France, too, we are pursuing such an approach. In the Paris region, we investigated whether the COVID-19 infodemic has had any effect on the risk perceptions, engagement in field activities, and protective practices of French Red Cross (FRC) volunteers in the Paris region (Heyerdahl et al. 2021). Specifically, we have tracked Twitter discussions and selected traditional media for seven months, evaluating all claims and debates about non-pharmaceutical protection measures. We also conducted interviews with FRC workers and volunteers. Thus far, although social and traditional media debates about viral risks and non-pharmaceutical interventions appear to aggravate anxieties among FRC volunteers and workers, their decisions to continue Red Cross field activities and daily protection practices like wearing masks appear to be affected by other factors that were not related to the infodemic. Familial and social obligations, gender expectations, financial pressures, FRC rules and communications, state regulations, and relations with co-workers all shaped their decisions.

The benefits of this type of approach provides insight into why individuals and social groups do not trust authoritative information sources. Building trust by cultivating dialogue, Heidi Larson (2020) has effectively contended, may do more to facilitate trust than fighting misinformation.

4 Conclusion

The COVID-19 infodemic has catalyzed considerable scholarly and public health attention, and the expanding literatures of infodemiology and infoveillance have extended our collective understanding of the dynamics and circulation of claims, stories, and advice—some true and some not. How this information epidemic shapes human action offline, however, remains less well understood. Drawing insights from anthropology and history to examine how and why social groups seek out and interpret certain claims, stories, and advice, and how they act on them, offers a fruitful avenue for more rigorous and robust tracing of online influences on offline behaviors.

References

Anwar A, Malik M, Raees V, Anwar A (2020) Role of mass media and public health communications in the COVID-19 Pandemic. Cureus 12(9):e10453. https://doi.org/10.7759/cureus.10453

Bala R, Srivastava A, Ningthoujam GD, Potsangbam T, Oinam A, Anal CL (2021) An observational study in Manipur State, India on preventive behavior influenced by social media during the COVID-19 pandemic mediated by cyberchondria and information overload. J Prev Med Public Health 54(1):22

Biasio LR, Bonaccorsi G, Lorini C, Pecorelli S (2020) Assessing COVID-19 vaccine literacy: a preliminary online survey. Human Vaccines Immunotherapeutics 1–9. https://doi.org/10.1080/21645515.2020.1829315

Britt RK, Collins WB, Wilson K, Linnemeier G, Englebert AM (2017) eHealth literacy and health behaviors affecting modern college students: a pilot study of issues identified by the american college health association. J Med Internet Res 19(12):e392. https://doi.org/10.2196/jmir.3100

Brown CW, Shepperson JT, Gopalan H, El-Amin S (2012) HIV: facts, fiction, and the impact on behavior of students at an historically black college/university. Int J Health Promot Educ 50(2):61–67. https://doi.org/10.1080/14635240.2012.661964

Bunker D (2020) Who do you trust? the digital destruction of shared situational awareness and the COVID-19 infodemic. Int J Info Manage 102201. https://doi.org/10.1016/j.ijinfomgt.2020.102201

Casigliani V, De Nard F, De Vita E, Arzilli G, Grosso FM, Quattrone F, Lopalco P et al (2020) Too much information, too little evidence: is waste in research fuelling the Covid-19 infodemic? BMJ, 370 m2672. https://doi.org/10.1136/bmj.m2672

Centola D (2010) The spread of behavior in an online social network experiment. Science 329(5996):1194–1197. https://doi.org/10.1126/science.1185231

Ceron A, Curini L, Lacus SM (2014) Social media e sentiment analysis: l'evoluzione dei fenomeni sociali attraverso la rete. vol 9. Springer Science and Business Media
Ceyssens R (1975) Mutumbula, mythe de l'opprimé. Cultures Et Dévelop 7(3–4):483–550
Chary MA, Overbeek DL, Papadimoulis A, Sheroff A, Burns MM (2020) Geospatial correlation between COVID-19 health misinformation and poisoning with household cleaners in the Greater Boston Area. Clin Toxicol 59(4):320–325
Compton J (2013) Inoculation theory. In: The sage handbook of persuasion: develop theory practice. vol 2. pp 220–237
Compton J, Jackson B, Dimmock JA (2016) Persuading others to avoid persuasion: inoculation theory and resistant health attitudes. Front Psychol 7:122
Cook J, Lewandowsky S, Ecker UK (2017) Neutralizing misinformation through inoculation: exposing misleading argumentation techniques reduces their influence. PloS one 12(5):e0175799
Donovan J (2020) Social-media companies must flatten the curve of misinformation. Nature. https://doi.org/10.1038/d41586-020-01107-z
Doornwaard SM, Ter Bogt TF, Reitz E, van den Eijnden RJ (2015) Sex-related online behaviors, perceived peer norms and adolescents' experience with sexual behavior: testing an integrative model. PloS one 10(6):e0127787. https://doi.org/10.1371/journal.pone.0127787
Dubey S, Biswas P, Ghosh R, Chatterjee S, Dubey MJ, Chatterjee S, Lavie CJ (2020) Psychosocial impact of COVID-19. Diabetes Metab Syndr 14(5):817–823
Durand JY, Cunha MI (2020) 'To all the anti-vaxxers out there…': ethnography of the public controversy about vaccination in the time of COVID-19. Soc Anthropol
Eysenbach G (2002) Infodemiology: the epidemiology of (mis)information. Am J Med 113(9):763–765. https://doi.org/10.1016/S0002-9343(02)01473-0
Eysenbach G. (2009) Infodemiology and infoveillance: framework for an emerging set of public health informatics methods to analyze search, communication and publication behavior on the internet. J Med Internet Res 11(1):e11. https://doi.org/10.2196/jmir.1157
Eysenbach G (2020) How to fight an infodemic: the four pillars of infodemic management. J Med Internet Res 22(6):e21820. https://doi.org/10.2196/21820
Fairhead J, Leach M, Small M (2006) Where techno-science meets poverty: medical research and the economy of blood in the Gambia. West Africa Soc Sci Med 63(4):1109–1120. https://doi.org/10.1016/j.socscimed.2006.02.018
Gallotti R, Valle F, Castaldo N, Sacco P, Domenico MD (2020) Assessing the risks of 'infodemics' in response to COVID-19 epidemics. Nature Human Behaviour 1—9. https://doi.org/10.1038/s41562-020-00994-6
Geissler PW, Pool R (2005) In: Medical anthropology. United Kingdom, McGraw-Hill Education
Geissler PW, Pool R (2006) Popular concerns about medical research projects in sub-Saharan Africa–a critical voice in debates about medical research ethics. Trop Med Int Health 11(7):975–982
Graboyes M (2015) The experiment must continue: medical research and ethics in East Africa, 1940–2014. Ohio University Press, Athens, Ohio
Greco F, Polli A (2019) Vaccines in Italy: the emotional text mining of social media. Rivista Italiana Di Economia Demografia e Statistica 73(1):89–98
Heyerdahl LW, Vray M, Leger V, Le Fouler L, Antouly J, Troit V, Giles-Vernick T (2021) Evaluating the motivation of red cross health volunteers in the COVID-19 pandemic: a mixed-methods study protocol. BMJ Open 11(1):e042579
Islam MS, Sarkar T, Khan SH, Kamal A-HM, Hasan SMM, Kabir A, Seale H (2020) COVID-19–related infodemic and its impact on public health: a global social media analysis. Am J Trop Med Hyg 103(4):1621–1629. https://doi.org/10.4269/ajtmh.20-0812
Kaler A (2004) The moral lens of population control: condoms and controversies in southern Malawi. Stud Fam Plann 35(2):105–115
Kaler A (2009) Health interventions and the persistence of rumour: the circulation of sterility stories in African public health campaigns. Soc Sci Med 68(9):1711–1719

King AJ, Lazard AJ (2020) Advancing visual health communication research to improve infodemic response. Health Commun 35(14):1723–1728. https://doi.org/10.1080/10410236.2020.1838094

Kozinets RV (2015) In: Netnography: redefined, SAGE Publications

Krieg LJ, Berning M, Hardon A (2017) Anthropology with algorithms? an exploration of online drug knowledge using digital methods. Med Anthropol Theory 4(3):21–52

Larson HJ (2020) Stuck: how vaccine rumors start–and why they don't go away. Oxford University Press, New York

Lee JJ, Kang K-A, Wang MP, Zhao SZ, Wong JYH, O'Connor S, Shin S (2020) Associations between COVID-19 misinformation exposure and belief with COVID-19 knowledge and preventive behaviors: cross-sectional online study. J Med Internet Res 22(11):e22205–e22205. https://doi.org/10.2196/22205

Lewandowsky S, Van Der Linden S (2021) Countering misinformation and fake news through inoculation and prebunking. European Rev Soc Psychol 1–38. https://doi.org/10.1080/10463283.2021

Luo Y, Yao L, Zhou L, Yuan F, Zhong X (2020) Factors influencing health behaviours during the coronavirus disease 2019 outbreak in China: an extended information-motivation-behaviour skills model. Public Health 185:298–305

Mackey TK, Li J, Purushothaman V, Nali M, Shah N, Bardier C, Liang B et al. (2020) Big data, natural language processing, and deep learning to detect and characterize illicit COVID-19 product sales: infoveillance study on twitter and instagram. JMIR Public Health Surveillance 6(3):e20794. https://doi.org/10.2196/20794

Marin L (2020) Three contextual dimensions of information on social media: lessons learned from the COVID-19 infodemic. Ethics Info Technol 1–8. https://doi.org/10.1007/s10676-020-09550-2

Marino C, Gini G, Vieno A, Spada MM (2018) The associations between problematic Facebook use, psychological distress and well-being among adolescents and young adults: a systematic review and meta-analysis. J Affect Disord 226:274–281. https://doi.org/10.1016/j.jad.2017.10.007

Martínez-Ferrer B, Moreno D, Musitu G (2018) Are adolescents engaged in the problematic use of social networking sites more involved in peer aggression and victimization? Front Psychol 9:801. https://doi.org/10.3389/fpsyg.2018.00801

McGuire WJ (1964) Inducing resistance to persuasion. Some contemporary approaches. In Berkowitz L (ed) Advances in experimental social psychology, vol 1. pp 191–229. https://doi.org/10.1016/S0065-2601(08)60052-0

Moreno MA, Whitehill JM (2014) Influence of social media on alcohol use in adolescents and young adults. Alcohol Res 36(1):91–100

Naeem SB, Bhatti R, Khan A (2020) An exploration of how fake news is taking over social media and putting public health at risk. Health Info Libr J. https://doi.org/10.1111/hir.12320

Neter E, Brainin E (2019) Association between health literacy, eHealth literacy, and health outcomes among patients with long-term conditions: a systematic review. Eur Psychol 24:68–81. https://doi.org/10.1027/1016-9040/a000350

Okan O, Bollweg TM, Berens E-M, Hurrelmann K, Bauer U, Schaeffer D (2020) Coronavirus-related health literacy: a cross-sectional study in adults during the COVID-19 infodemic in Germany. Int J Environ Res Public Health 17(15). https://doi.org/10.3390/ijerph17155503

Pelagalli F, Greco F, De Santis E (2017) Social emotional data analysis. The map of Europe. In: Petrucci AV, Rosanna (ed) Statistics and data science: new challenges, new generation, pp 779–784

Pulido CM, Villarejo-Carballido B, Redondo-Sama G, Gómez A (2020) COVID-19 infodemic: more retweets for science-based information on coronavirus than for false information. Int Sociol 35(4):377–392. https://doi.org/10.1177/0268580920914755

Ratzan SC, Sommariva S, Rauh L (2020) Enhancing global health communication during a crisis: lessons from the COVID-19 pandemic. Public Health Res Pract 30(2). https://doi.org/10.17061/phrp3022010

Rosário R, Martins MRO, Augusto C, Silva MJ, Martins S, Duarte A, Dadaczynski K et al (2020) Associations between COVID-19-related digital health literacy and online information-seeking behavior among portuguese university students. Int J Environ Res Public Health 17(23):8987.https://doi.org/10.3390/ijerph17238987

Rovetta A, Bhagavathula AS (2020) COVID-19-related web search behaviors and infodemic attitudes in Italy: infodemiological study. JMIR Public Health Surveillance 6(2):e19374. https://doi.org/10.2196/19374

Safarnejad L, Xu Q, Ge Y, Bagavathi A, Krishnan S, Chen S (2020) Identifying influential factors in the discussion dynamics of emerging health issues on social media: computational study. JMIR Public Health Surveillance 6(3):e17175. https://doi.org/10.2196/17175

Saran I, Fink G, McConnell M (2018) How does anonymous online peer communication affect prevention behavior? evidence from a laboratory experiment. PloS One 13(11):e0207679. https://doi.org/10.1371/journal.pone.0207679

Scheper-Hughes N (2001) Commodity fetishism in organs trafficking. Body Soc 7(2–3):31–62. https://doi.org/10.1177/1357034x0100700203

Sentell T, Vamos S, Okan O (2020) Interdisciplinary perspectives on health literacy research around the world: more important than ever in a time of COVID-19. Int J Environ Res Public Health 17(9). https://doi.org/10.3390/ijerph17093010

Sharma DC, Pathak A, Chaurasia RN, Joshi D, Singh RK, Mishra VN (2020) Fighting infodemic: need for robust health journalism in India. Diabetes Metab Syndr 14(5):1445–1447. https://doi.org/10.1016/j.dsx.2020.07.039

Southwell BG, Niederdeppe J, Cappella JN, Gaysynsky A, Kelley DE, Oh A, Chou W-YS (2019) Misinformation as a misunderstood challenge to public health. Am J Prev Med 57(2):282–285. https://doi.org/10.1016/j.amepre.2019.03.009

Stalcup M (2020, 2020/03/16/T18:41:57+00:00). The invention of infodemics: on the outbreak of zika and rumors. Retrieved from files/2959/infodemics-zika.html.html

Tangcharoensathien V, Calleja N, Nguyen T, Purnat T, D'Agostino M, Garcia-Saiso S, Briand S et al (2020) Framework for managing the COVID-19 infodemic: methods and results of an online, crowdsourced WHO technical consultation. J Med Internet Res 22(6):e19659. https://doi.org/10.2196/19659

Tappan J (2014) Blood work and "Rumors" of blood: nutritional research and insurrection in Buganda, 1935–1970. Int J Afr Hist Stud 47(3):473–494

Tran BX, Huong LT, Hinh ND, Nguyen LH, Le BN, Nong VM, Ho RC et al. (2017) A study on the influence of internet addiction and online interpersonal influences on health-related quality of life in young Vietnamese. BMC Public Health 17(1):138. https://doi.org/10.1186/s12889-016-3983-z

White L (2000) Speaking with vampires: rumor and history in colonial Africa. University of California Press, Berkeley, CA

Zarocostas J (2020) How to fight an infodemic. Lancet 395(10225):676. https://doi.org/10.1016/s0140-6736(20)30461-x

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Chapter 5
Mapping COVID-19 in Japan and Greater Tokyo Area, Socio-Spatial and Political Analysis of the Epidemic

Adrienne Sala and Rémi Scoccimaro

Abstract This chapter provides a political analysis of the COVID-19 crisis management in Japan completed by a socio-spatial analysis during the first three waves of the epidemic. Introducing the infectious diseases legal framework to pinpoint the key notion of "responsibility" allows us to understand coordination among political, scientific, and economic actors, and citizens, at national and local levels, allowing the implementation of various measures applied to each new wave. We then highlight tensions, power relations, and conflicts of interest, before concluding on Japanese relationship between freedom and security raised by the COVID-19 global pandemic.

Keywords Crisis management · Socio-spatial analysis · Epidemic · Infectious disease · Japan · COVID-19

1 Introduction

Japan is one of the few liberal democracies having an extremely low death rate, despite a high and early exposure to the SARS-Cov-2, due to its proximity with China (business travellers, tourists, etc.) combined with a theoretically structural vulnerability caused by the high concentration of its populations in megacities,[1] where commuting travels are mixing millions of people every day,[2] and a significant ageing population.[3] On May 25, 2020, when the state of emergency was lifted, Japan

[1] 34 million inhabitants for the megalopolis of Tokyo and 20 million for the megalopolis of Osaka.

[2] Shinjuku is the world biggest station in term of daily number of commuters (3.6 million), JR East, www.jreast.co.jp (last visited on March 4, 2021).

[3] 28% of the population over the age of 65, half of whom, 14.7% of the population, are over the age of 75, Bureau National des Statistiques (www.stat.co.jp) (last visited on March 4, 2021).

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had a total number of 846 deaths and 16,706 cumulative cases. With 13 cases per 100,000 inhabitants, Japan was then among the good students along with its Asian neighbours. On February 27, 2021, as the third wave appears to be coming to an end, Japan experienced 429,000 cumulative cases and 7865 deaths.[4] The prevalence is 56.5 cases per 100,000 inhabitants. Moreover, the Japanese government did not use coercive measures or intrusive tracking of its population (except for people coming back from foreign countries).

However, analyses of Japanese crisis management do not all converge in the same direction, as critics pinpoint the national government's slow responsiveness, the entrenched bureaucracy and lack of transparency in the decision-making process.[5] Indeed, public authorities face multi-sectoral and multi-level issues, such as health, economic, social, and political issues, intertwined at the local, national, and global levels. Besides the coordination between political and economic actors and citizens is challenged by the long duration of the epidemic and its rising socio-economic consequences.

In this chapter we propose to give an overview of the Japanese policy anchoring the Covid-19 epidemic[6] in conjunction with a socio-spatial analysis. This highlights the main characteristics of the Japanese Covid-19 epidemic and its evolution in relation with public actions being pursued to prevent the spread of the virus.

1.1 Is Japan in Crisis Due to the COVID-19 Epidemic?

In Japan, the COVID-19 outbreak and its consequences fit only imperfectly with the definition of a crisis. For example, a crisis is defined as a significant threat to an organization that can have negative consequences if not handled properly (Coombs 2015). Although Japan did not experience the SARS and MERS epidemics, it has drawn lessons from older epidemics such as the Spanish flu to develop public policies on infectious diseases, including a surveillance system (Taniguchi et al. 2007). To respond to infectious diseases, public authorities can rely on alert systems, dedicated organizations to deal with well-known, already listed and anticipated threats to avoid further disruptions (Borraz et al. 2007). Nevertheless, as the literature highlights, crisis management plans are not always executed according to protocols due to political conflicts or economic interests; then, the nature of the response to the threat

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[4] MHLW (www.mhlw.go.jp/stf/covid-19/open-data.html) (last visited on March 4, 2021).

[5] *Shingata korona taiyô—minkan rinjichôsakai, chôsa-kenshô hôkokusho, ippandantaihôjin azia—pashifiku-inishiatibu,* October 2020 (*Novel coronavirus counter measures—civil society special survey, investigation report, Initiative Asia–Pacific, October 2020*).

[6] From the beginning of the epidemic, we did a regular survey of government publications, press, and media coverage. We also did a timeline of the COVID-19 epidemic in Japan on a dedicated website published by the IRFJ-MFJ: "Site d'information sur le Covid-19 au Japon par les chercheurs de l'IFRJ-MFJ". *World Pandemic Research Network*. WPRN-457952, 2020-06-09 at 06h37 (GMT): https://wprn.org/item/457952; http://covid19-ifrjmfj-tokyo1.e-monsite.com/blog/publications-officielles.html.

might become an additional risk. For example, in most countries, confusion between different public authorities, creation of ad hoc expertise and improvised coordination mechanisms, such as bypassing existing structures, lead to a blurring of boundaries and jurisdictional struggle that amplified the current crisis (Bergeron et al. 2020).

While the Japanese government was quick to recognize the seriousness of the warnings coming from China, introducing a graduated response, it nevertheless made decisions (or non-decisions) that triggered the crisis: the closure of schools, the late closure of borders, the state of emergency, the voluntary lockdown, to quote just a few. We then argue that it is not the virus itself but the political decisions that might have amplified the crisis in Japan.

Based on ‘t Hart and Boin’s definition of a modern crisis, a crisis is not spatially confined by common boundaries, it entangles quickly with other deeply rooted problems, and its impact is long lasting and generates both a loss of reference, political confusion, as well as a leadership crisis (’t Hart and Boin 2003). Hence, the Japanese case meets these criteria. Additionally, the very use of the term "crisis" by political leaders can often be used as an opportunity to centralize power, opposing a consultative approach and decision-making process efficiency. However, effective crisis management does not always require the centralization of power, as such centralization displaces authority away from entitled actors, diminishing their ability to comply with political leaders’ expectations rather than improving results.

Japanese policy anchoring the Covid-19 epidemic sheds light on a delicate balance between centralization and multi-level coordination on which depends the effectiveness of the coordination between political and economic actors and citizens.

2 Legal Framework and COVID-19 Countermeasures: Multi-level Policy and Three Pillars Coordination

The Communicable Disease Prevention Law enacted in 1898 has long provided the legal framework for infectious disease control in Japan. The basic policy was the traditional attempt to prevent the massive spread of infectious disease by notification and subsequent isolation and quarantine. Thus, mandatory reporting of national disease was the only system for infectious disease surveillance. In the 1990s, the circumstances surrounding infectious diseases changed drastically, such as globalization of travel and trade, animal diseases crossing into human populations, and accidental or deliberate release of biological agents (Taniguchi et al. 2007). In such circumstances**,** policies concerning infectious diseases were completely revised. The 1898 Infectious Disease Control Act was revised for the first time and the Law Concerning the Prevention of Infectious Diseases and Patients with Infectious Diseases (Infectious Diseases Law) was enacted in 1999 to emphasize the promotion of infectious disease prevention (Nomura et al. 2003).

This reform represents a turning point in Japanese infectious disease public policy. The new policy is based on the belief that there are basic countermeasures that are

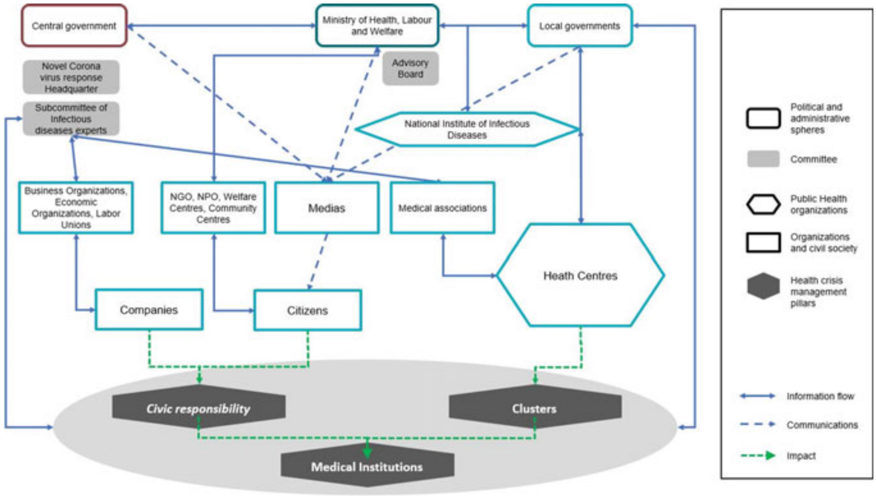

Fig. 1 Japanese COVID-19 epidemic political and sanitary counter-measures management coordination. *Source* Author

common to all types of infectious diseases, including the creation of an adequate surveillance system, which led to the formulation of a national strategy for fighting infectious diseases. In fact, the Japanese government chose to emphasize a more comprehensive approach and developed policy guidelines around eight pillars: (1) investigation of causes; (2) prevention of infection and further spread; (3) provision of medical care; (4) promotion of research and development; (5) participation in international networks; (6) respect for human rights; (7) provision of information and education; and (8) creation of new ties with relevant ministries, local governments, and non-governmental organizations (NGOs). This new law provides the legislative framework to a potential health crisis caused by infectious disease.

In 2012 an emergency system specifically designed for influenza was created based on the enactment of the Special Measures Act on New Influenza. It was revised on March 14, 2020 to add COVID-19. Under this Act, the Ministry of Health, Labour and Welfare, local governments, health centres and the National Institute of Infectious Diseases monitor and report on the outbreak of infectious diseases and coordinate their roles to prevent more infections (Umeda 2015). Japan also designated hospitals with special facilities to deal with patients who are infected with serious and highly infectious diseases. This multi-level infectious disease policy has been applied to respond to the COVID-19 outbreak and is articulated around three main pillars (see Fig. 1).[7]

[7] Prime Minister Office of Government of Japan. Available at http://japan.kantei.go.jp/ongoingtopics/_00013.html (last visited on February 12, 2020).

2.1 First Pillar: Medical and Health System

According to WHO reports, Japan's healthcare system ranks among the best in the world. In 2018, health expenditures accounted for 10.9% of GNP and life expectancy is one of the longest in the world, although it faces major issues such as an ageing population, rising chronic diseases, healthcare spending, and a lack of healthcare professionals and doctors (2.35 per 1 000 inhabitants). The number of beds, at 13.2 beds per 1000 inhabitants in 2015 is well above the OECD average; however only 0.2% (1841 beds) were reserved for infectious diseases (Sakamoto et al. 2018).

Since March, the Japanese government significantly increased the number of beds, enhanced intensive care responses via securing medical services system for severely ill patients, including medical equipment (ventilator, ECMO, etc.).

2.2 Second Pillar: Early Detection of and Early Response to Clusters—Epidemiological Investigations

In 1999, according to the new law, infectious disease surveillance was designated as one important component for disease control and was revised and incorporated as the national epidemiological surveillance for infectious diseases. The national and prefectural/municipal infectious disease surveillance centre was organized to play a central role in implementing surveillance and information dissemination (Taniguchi et al. 2007). Thus, identifying clusters through epidemiological surveys was the first phase of the policy to fight the Sars-Cov-2 (Tashiro and Shaw 2020). All physicians must inform the health centre (*hokenjo*) when a case of infectious disease is detected. The health centre then deploys contact tracing procedures. More than 500 health centres are present throughout the country, representing one of the major structures involved in public health management.

Rather than aiming at identifying and quarantining infected people, the main objective of epidemiological investigation is to determine factors behind the spread of the virus in order to rapidly apply targeted measures.

2.3 Third Pillar: Individual, Collective, and Civic Responsibility

According to article 4 of the Infectious Diseases Law, which defines civil society responsibilities, "the public must endeavor to acquire accurate knowledge on infectious diseases and to exercise vigilance in order to prevent infectious diseases." This is the legal basis for the third pillar, civic responsibility. This responsibility is based on the assumption that civil society and citizens have the necessary knowledge to contribute to the prevention of infectious disease propagation.

As mentioned above "provision of information and education" is one component of the new policy guidelines implemented in 1999 to prevent the spread of infectious diseases. For example, restrictions requested by the national government and local governors are relayed through regular risk communication via traditional media and social networks, encouraging individual and collective risk management. These "voluntary restrictions" (until early 2021) combine individual and collective responsibility into a civic responsibility (Sala 2020).

The social acceptance of the widespread wearing of masks' is also the result of successive epidemic episodes. Whereas in Europe and the United States surgical masks wearing was the subject of intense controversies, the practice gradually became widespread in Japan, from the Spanish flu (1918–1919), the Italian flu (1949–1950), the Hong Kong flu (1966–1968), SARS in 2003, and the swine flu in 2009, transforming the practice into a social norm. Since 2009 by protecting the individual and the community, the wearing of masks has been the subject of regular media information campaigns and corporate internal communication. This is also an illustration of the coordination between the state and economic actors in civic education and dissemination of behavioural norms: the wearing of masks has become a symbol of respect and responsibility among workers in the same way as hygiene rules (Burgess and Horii 2012).

This third pillar is activated at different levels according to the epidemic risk evolution from daily barrier gestures (wearing a surgical mask, hand washing, physical distance, not speaking loudly, etc.) to "voluntary restrictions" (staying home, closing schools, teleworking, closing shops, etc.). This is the highest level of civic responsibility as public authorities ask for citizens' acceptance without coercive measures.

While the Japanese government decided not to carry out systematic PCR tests due to technical constraints (lack of tests and qualified personnel), this has been partially remediated by a coordinated application of the three pillars in accordance with the legal framework and the national strategy to prevent infectious diseases (Tashiro and Shaw 2020).

3 Socio-Spatial and Political Approaches of the COVID-19 Counter-Measures

3.1 The First Wave—From January to End of May 2020: Mixed Political and Sanitary Responses

From early February 2020, clusters identification was the first priority. Mid-February preventive measures were implemented through recommendations for citizens, published on the websites of various ministries, such as basic hygiene rules (washing hands, sneezing and coughing into one's elbow, wearing a mask), and voluntary isolation in case of symptoms (including colds and flu). The government increased hospitals capacities (number of beds) and specific care (respiratory assistance device equipment), with reinforced hospital structures dedicated exclusively to infectious diseases. On February 27, despite the lack of legal authority to do so, Prime Minister Shinzô Abe requested the closure of primary, middle, and high schools for two weeks.[8] On February 28, the young governor of Hokkaido, Naomichi Suzuki, declared a local non-official "state of emergency" to halt the uncontrolled rise of the epidemic.[9] Hokkaido Prefecture counted 63 cases out of 195 cases in Japan (32% of infections) with the largest daily increase (12 additional cases between February 27 and 28, 2020).[10] The inhabitants were solemnly asked to voluntary lockdown. With a population of five million, Hokkaido had only 94 intensive care beds. Hokkaido was the first prefecture to implement a genuine attempt at lockdown without legal basis and might have been considered as a model to follow.

On the eve of a three-day weekend on March 19, the number of isolated cases imported from abroad increased in major cities (Tokyo, Osaka, Nagoya), worrying the members of the scientific advisory committee.[11] The mayor of Kobe and the governor of Osaka called on citizens to limit their movements across prefectures, asking for voluntary lockdown. The same day, the Hokkaido governor announced the end of the three-week state of emergency in response to the drop in new cases numbers,[12] while requesting continuation of the voluntary lockdown during weekends.[13]

On March 25, the governor of Tokyo, Yuriko Koike, recommended to the inhabitants of the capital to limit outings and travel during the next weekend (gradual closure of many restaurants, karaoke bars, cinemas, and promotion of teleworking). The governors of Chiba, Saitama and Kanagawa prefectures asked citizens not to travel to Tokyo.

From end of March local governors called for an official declaration of a state of emergency. Yoshihide Suga, then Chief Cabinet Secretary, declared on March 31, that it was not yet necessary.[14] However, on April 7, in response to hospitals congestion, increasing isolated cases, and a loss of overall control of the epidemic, the national government declared a state of emergency based on the March 14, 2020 amendment of

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[8] Despite a few cities, such as Kanazawa, that announced that they would not follow the recommendations, most public schools complied ("Despite Abe's request, some schools to remain open next week", *Asahi Shimbun*, February 28, 2020).

[9] Hokkaido declares state of emergency over coronavirus, *Kyodo news*, February 28, 2020.

[10] The contamination comes mainly from Chinese tourists, but not only, and if the main cluster was identified in Sapporo, another one was in Kitami, in the far east of the island ("Hokkaido grapples with coronavirus emergency", NHK, March 2, 2020).

[11] The prefectures of Osaka and Hyôgo—100 cases and 69 cases respectively, 0.67 contamination per 100,000 inhabitants, the same as Hokkaido, when Tokyo was still 0.26/100,000.

[12] After peaking at the end of February, with 15 new cases per day, no more cases are reported after March 17, 2020 in Hokkaido until June.

[13] It turns out that residents have been following the calls for voluntary lockdown rather seriously: Asahi Shimbun, *Shinkorona vairusu no kansen jôkyô* (Situation of contamination with new type of coronavirus), special statistical collection Covid19 online, www.asahi.com/special/corona/. Asahi Shimbun March 19, 2020, "New virus cases fall in Hokkaido; state of emergency to end".

[14] "Abe, Suga flatly deny a state of emergency is imminent", Asahi Shimbun, March 31, 2020.

the Special Measures Act on New Influenza, allowing local governors to declare local states of emergency and take broader measures. Application of the state of emergency, together with a major economic plan to tackle the socio-economic consequences of the restrictions, allowed the government to proceed with the activation of civic responsibility to support the other two pillars.[15]

3.1.1 The First Wave Socio-Spatial Analysis

While at the individual level, the Japanese epidemic shares some common aspects with other countries, (particularly in age distribution, entry of contamination, and mortality of the elderly) at the socio-spatial level, the situation shows some specificities. Although we do not have access to infected people income, the spatial distribution leads us to hypothesize that the COVID-19 first wave affected mostly the higher-income level of the population. The patient's place of residence provides indeed an indicator of their social affiliation, and the mapping of the epidemic in June, on the scale of the Great Tokyo, thus brought back the historical socio-spatial dichotomy of the city (Fig. 2).

The first wave of contaminations happened in the most internationally exposed territories, followed by secondary regions, and finally the most closed and isolated areas. For example, Iwate prefecture did not record any case until July 29, 2020. The decline of new cases followed the same logic, namely a decrease from outside to central areas. During the first wave, Tokyo was the most affected area (139.7 cases per 100,000 inhabitants, followed by Okinawa with 131.5, and Osaka with 89.7). While the most populous ward (Setagaya-ku) registered the highest number of confirmed cases, Minato ward had, until June and the second wave, the highest proportional concentration of positive cases (Fig. 3).[16]

In consequence, while the partial lockdown measures restricted white-collar workers from commuting to cities central areas, many blue-collar workers continued to work. Large groups, such as Toshiba or Sony, asked their office workers to stay at home, switching to telecommuting, but many factory workers still went to work.[17] Considering the spatial distribution of the first wave, the state of emergency, the goal of which was to reduce by 80% the commuting to big cities' central areas, achieved the expected outcome at the expense of individual liberties restriction, even at a moderate level compared to other liberal democratic states (Fig. 3).

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[15] The maximum number of cases per day was reached on April 12, with 743 cases recorded in one day (including 197 in Tokyo, 28% of total cases, followed by Fukuoka with 108 new cases), then a second peak on April 18, with 627 people recorded, 201 of them in Tokyo (32% of the total contaminations) and 70 in Chiba. The long-term decline in the number of cases took place from May 3, after the Golden Week. Then the downward trend set in at a steady rate of about 40 cases a day.

[16] Nikkei Shinbun, *Châto de miru nihon no kansen jôkyô shingata koronawirusu* (The situation of the Covid-19 epidemic in Japan in graph), August 19, 2020.

[17] "Thousands work from home as Sony and Takeda join telework", Nikkei Asia, February 19, 2020.

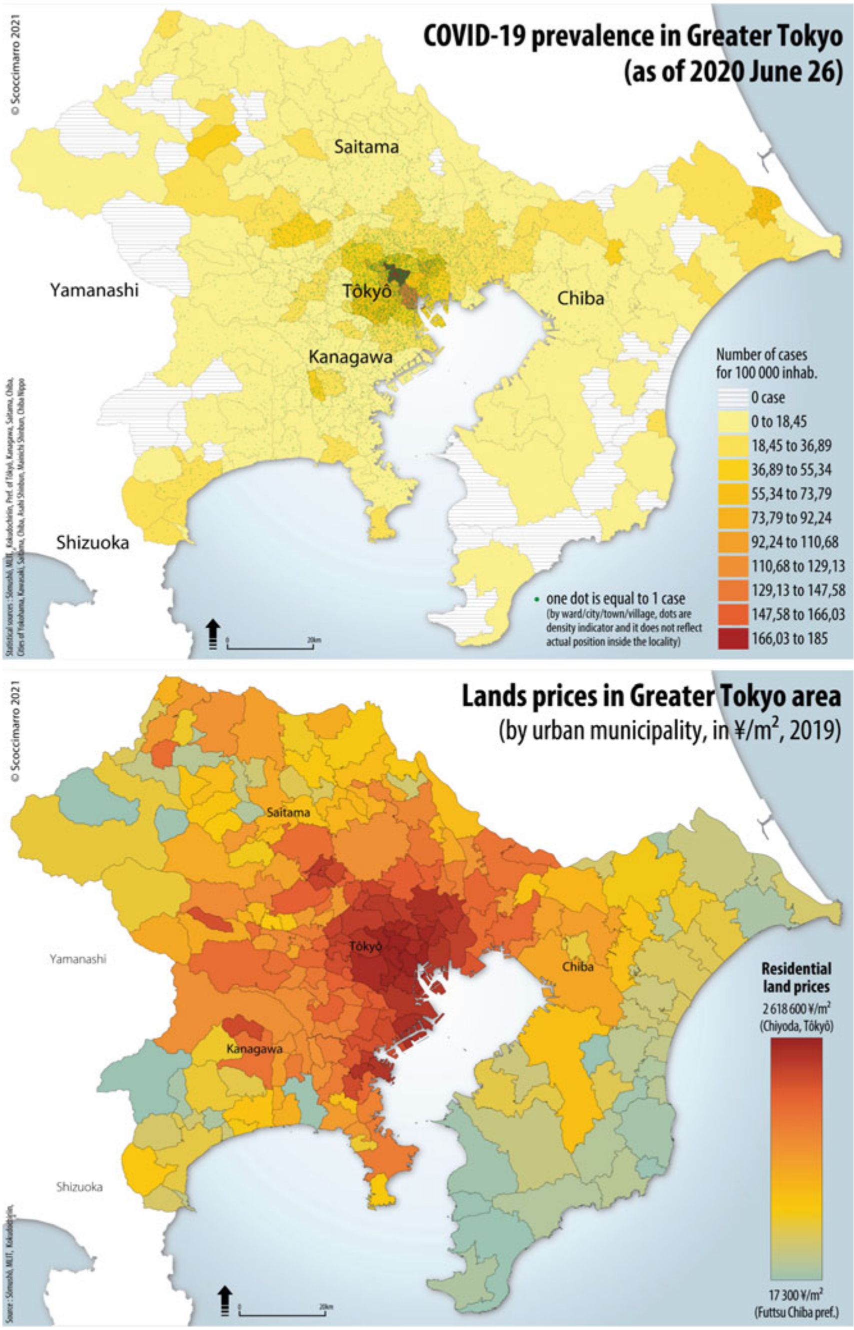

Fig. 2 Prevalence of COVID-19 on June 26 and residential land price (2019) in greater Tokyo

Fig. 3 Tokyo Hypercentral District of Ginza (above), April 15. The banks of the Tama River in Setagaya ward (below), April 29, 2020, public holiday, during the "voluntary lockdown" ©Scoccimarro 2020

3.1.2 Policy Decision-Making Centralization, Conflict of Interests, and Lack of Coordination: The COVID-19 Political Crisis

This first wave highlights mitigated political and sanitary responses. Early application of infectious diseases preventive and sanitary procedures in accordance with the legal framework allowed the activation of the surveillance system to investigate the causes and prevent the spread of the infection. For example, early March the results of these investigations, conducted also on the cruise ship *Diamond Princess*, allowed identifying key contagion vectors of the virus, summarized and communicated through the terms "san mitsu" or "three Cs", referring to closed places (*mippei*), crowded places (*misshû*) and places with close proximity between individuals (*missetsu*) (Oshitani et al. 2020). These scientific results were disseminated and used by public authorities in their risk communication. Information and education also allowed the activation of barrier gestures among Japanese citizens. But, although the health and medical system provided medical care, at the end of March, hospitals were not prepared and equipped enough to face the rising number of new contaminations. It would appear that the comprehensive infectious diseases countermeasures failed to contain the spread of the Sars-Cov-2 virus.

According to Olivier Borraz, analyzing the French government crisis management, it is not the virus itself but the decisions that provoked the crisis (Borraz 2021). Indeed, Boin and t'Hart (2003) highlight that it is up to the public authorities to define the nature of the crisis, its causes and consequences, and the organizations that will be responsible for it; in other words, to do the political work of framing it.

The first wave shows that despite an apparent multi-actor' coordination process, the Japanese government applied general measures, reflecting a lack of anticipation and comprehension of the virus diffusion factors and risk behaviours. For example, the closure of schools, whereas bars and restaurants as well as international borders were still opened, illustrates the limited efficiency of centrally issued policy directives. The closure of schools was considered as an arbitrary measure taken outside the framework of a state of emergency. It was not the result of any consultation with the Ministry of Health, Labour and Welfare, the Ministry of Education, local governments, and the expert advisory committee.[18] The lack of structures sufficiently deployed upstream of this decision-making process to help families organize themselves, particularly through teleworking, reflects the lack of coordination between the political, administrative, business, and citizen spheres to enable the coherent application of the third pillar—civic responsibility. The repercussions of these measure on mental health, education, and work–life balance were also significant[19] (Yamamoto et al. 2020).

This measure illustrates differences between the common beliefs that decision-making process must be centralized whereas crisis-response efforts strongly depend on many people in several networks ('t Hart et al. 1993). As Benini (1999) points out,

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[18] Sasaki, Asami et al. "Evidence-based tool for triggering school closures during influenza outbreaks, Japan." *Emerging infectious diseases* vol. 15, 11 (2009).

[19] "Stay home" plan taking a toll on overburdened, lonely mothers, Asahi Shimbun, May 9, 2020.

efforts to radically centralize decision-making authority tend to cause more friction than they resolve because they disturb well-established authority patterns. Moreover, at the operational-response level, centralization is near impossible, because many dynamic, situation-specific, and urgent problems arise simultaneously at different places and nodes in the response (Boin and t'Hart 2003).

In mid-March, the decision to reopen schools despite the epidemic worsening situation (scientific advisory committee issued emergency recommendations), led to a new confusion in the preventive policy-making. This lack of policy consistency altered citizens' risk perception before the three days week-end for the spring equinox, during which the cherry blossoms attract a large number of people to public places, restaurants and bars every year. The poor risk communication from the national government contrasted with some local governors' reactivity (Hokkaido, Osaka, Wakayama) highlighting a lack of both consensual political framing of the crisis and shared risks level definition.

Finally, this first wave is characterized by a constant lag between the evolution of the epidemic and the political measures implemented by the national government leading to the state of emergency declaration and individual liberty restrictions. The national government has been slow to implement targeted measures corresponding to the identification of clusters, revealing the existence of a gap between the temporality of the virus and the temporality of public actions.

The successful decreasing number of new contaminations resulting from the voluntary lockdown highlights citizens' compliance with the government policies. Nevertheless, effectiveness of the coordination between political and economic actors and citizens is challenged by the long duration of the epidemic and its socio-economic consequences, specifically on lower income groups.

3.2 The Second Wave (from End of June to Mid-September): A Multi-level Coordination

After the lifting of the state of emergency and despite the coordination issues the then prime minister Shinzô Abe qualified the successful COVID-19 crisis management as a "Japanese model" highlighting the role of leadership in time of crisis. However, bureaucratic and political leaders' responses to effectively remediate the crisis were questioned and criticized. For example, the need to integrate socioeconomic players into a more transparent decision-making process led, early June, to a reconfiguration of the experts advisory committee into a subcommittee composed of half scientific and medical experts, and half economic and political actors.[20] The new policy goal was to maintain economic activities along with COVID-19 preventive measures. This reinforced coordination between medical experts, public authorities, and economic actors, sheds light on experts' crucial role, not exclusively to

[20] Prime ministry secretary cabinet coronavirus headquarter, July 2, 2020; 40th committee, https://corona.go.jp/expert-meeting/pdf/sidai_r020703.pdf.

monitor the epidemic, but also to enable economic support measures application. For example, tourism, restaurants, and hotels—which represent one of the most affected sectors—are supported by the "Go to" campaign, which aims at stimulating consumption during the return to a "new normal" period. The campaign relied on a reinforced surveillance system, clusters identification, and information and educative provision to encourage civic responsibility. The launch of this campaign highlights the governmental choice to live with the virus rather than eradicate it.

3.2.1 Targeted Measures Application and Citizens' Compliance

As the first wave showed, the efficiency of public authorities' responses crucially depends on citizens' compliance with government policies. On June 12, the Diet voted the second supplementary budget to allow the government to implement substantial measures to protect the public, limit harm, and compensate damages. The amount was unprecedented both for a supplementary budget and in international comparison. This second budget was used in priority to support businesses through daily subsidies to maintain the jobs of employees whose activity was suspended, subsidies for the payment of rents, allowances for health personnel, financial support for about 400,000 university students to cover the loss of income, and financial measures implemented through public and private financial organizations. Although the Japanese economy is less impacted by the consequences of the epidemic than other countries, the effects of this policy are nuanced as shown by rising rates of unemployment, bankruptcy, and suicide (Ueda et al. 2020).

Since the end of June, the number of PCR tests increased significantly in response to new clusters identification in restaurants, bars, and night clubs located in specific areas (that is, Shinjuku, Tokyo). The government increased hotel capacity to quarantine tested positive individuals. Hospital capacity was also gradually increased to cope with the rise of confirmed cases (42,071 beds on August 21). This increase has kept the overall hospital occupancy rate relatively low during the second wave (27.4% on August 21).

On July 17, the Governor of Tokyo issued new guidelines to respond to the spread of the virus based on targetted measures for restaurants, bars, and nightlife venues. On August 7, the risk management policy was based on the articulation of five measures: rapid risk assessment, rapid identification of clusters, encouraging citizens' preventive behaviour based on the "3Cs", strengthening the capacity of health centres, and increasing the reception and care capacity of hospitals and hotels.[21] On August 24, the number of contaminations started to decline. Between September 4 and 25, the downward trend in the number of new contaminations and hospitalizations continued along with the measures taken in high-risk locations such as restaurants

[21] Advisory board, August 6, 2020; 5th committee, https://www.mhlw.go.jp/content/10900000/000657598.pdf.

Experts Sub commission August 7, 2020, 5th committee) https://www.cas.go.jp/jp/seisaku/ful/bunkakai/corona5.pdf.

and bars (application of a curfew at 10 p.m. and reinforced vigilance with regard to customers (taking their temperature, wearing a mask, hydro-alcoholic solution, partitioning between tables, cooperation from customers to avoid talking out loud, etc.)).

From June to September, a multi-level policy was reinforced at the prefectural and municipal levels to respond to specific local issues by applying targeted measures. Unlike the WHO recommendations "test, test, test" (test, trace, isolate), this strategy of coordinating the three pillars allowed a better understanding of the virus and risk behaviours. Lessons learned from the first wave and its application through targeted measures allowed the government to avoid generalized restrictions of individual liberties, which have deleterious socio-economic impact on the population as experienced during the state of emergency voluntary lockdown (Yamamoto et al. 2020).

3.2.2 The Second Wave Socio-Spatial Analysis

In July, early clusters were identified mainly among young people (20–30 years old) in entertainment districts of major cities before spreading to other areas. On August 24, Shinjuku ward maintained the highest rate with 698.4 cases for 100,000 inhabitants, followed by Minato ward with only 367.7 cases and Shibuya ward with 302.8 cases (Fig. 4). Shinjuku ward has the highest daily number of positive cases (on August 24, 2438 cases were registered, followed by Setagaya ward, 1570 cases, and

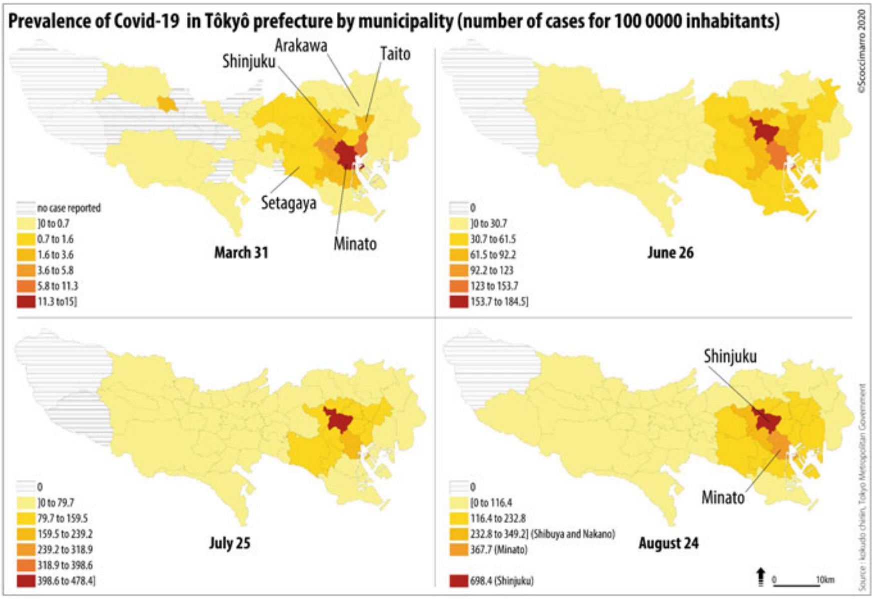

Fig. 4 The surge of case in Shinjuku Ward after second wave

Minato ward, 958 cases). In August the virus continued to spread with the higher rates in Shinjuku and the western upper side of the capital such as Shibuya and Nakano. Northern, eastern wards of Tokyo as well as the suburban towns and cities have a lower rate, under 120 cases for 100,000 inhabitants at the end of August (Fig. 4).

Shinjuku is very heterogeneous with Tokyo's second central business district, a residential area, as well as the red-light district of Kabukichô, adjoining the Shinjuku station, where bars, restaurants, hostess bars, and places for male and female prostitution are concentrated with little control by the police. Collecting clientele data to trace the routes of contamination is a difficult task; however it is within these populations that the authorities identified since June the largest increase in contamination, especially among young age groups. The second wave did call into question the socio-spatial distribution observed during the first wave. The second wave is endogenous, the population affected is more heterogeneous with a higher proportion of lower income than the first wave.

In this area social pressure tools and incentives for civic responsibility may have little influence. To overcome resistance towards testing and support health centre cluster tracking, a 100,000 yen subsidy might have prompted some of these populations to be tested; local authorities leveraged alternative collectivities tools to reduce the spread of the virus in those communities.

3.2.3 The Second Wave Efficient Targeted Measures: Actors Coordination at Community Level

During the second wave, PCR testing for at-risk population increased and risk communication improved. The media (traditional and government media) were used as an "intervention technology" on public policy targets identified through epidemiological investigations (Foucault 2004). Intermediary actors such as non-profit organizations (NPOs) and non-governmental organizations (NGOs) were also used to disseminate information to communities that the media and public authorities can hardly sensitize. The activation of these intermediary groups to target hard-to-reach populations was based on early 2000s experience acquired during HIV prevention in areas such as Shinjuku 2-chôme. For example, NGOs and community centres members established interpersonal relationships and social ties with local gay communities to build trust. This lay the social foundation for NGOs' local operations in coordination with municipalities and local actors.

The second wave is characterized by the individual citizen construction as rational and capable of self-vigilance committed to developing self-reflective skills (Levay 2009). From the end of the state of emergency, preventive measures crystallize on this ideal type of autonomous and self-vigilant individual. For example, the Tokyo governor maintained a high risk-awareness by setting-up a "Tokyo Alert" system, which consisted in colouring the rainbow bridge in red when the level of contamination reached a high level. It then mechanically activates a crisis protocol that would be integrated by each citizen individually (voluntary restrictions on travels, outings, working from home, etc.). The same ideal type was used by Prime Minister

Suga through his campaign slogan (jijyô—kyûjyô—kojyô—self-help, social solidarity care, and government care). These three levels—individual, community, and government—are coordinated to sustain economic activities, hence preserving the general interest. The civic responsibility pillar might support a liberal policy based on the representation of an autonomous citizen, who cannot be prohibited from carrying out behaviours that he considers to be part of his free will (Berlivet 2004). Thus, it is not so much the protection of individual liberties that determines public actions, but the preservation even at a moderate level of economic activity. Indeed, the Japanese company-ism structure is based on the economic activity of the social agents on which also depends the structure of the family, social relations, and financial resources (Dore 1990). Containing at a moderate level the economic consequences of the current epidemic represents a major condition for maintaining the compromise between freedom and security on which the Japanese crisis policy is based.

More generally, the gap between citizens' expectations and leadership efforts in preventing and containing crises characterizes the "risk society" (Beck 1992). The COVID-19 pandemic undermines the central roles of the democratic state, which are the protection of civil liberties (freedom of expression, right to privacy, right to assembly, free movement, etc.) and the provision of public good. It dramatically interrogates how citizens view the trade-offs between civil liberties and improved public health conditions. The different ways that government can be responsive to the preferences of the citizenry crucially depend on the compliance with the policies they implemented and the degree to which citizens agree with such policies. According to a recent survey, the citizens of Japan and the US tend to be the least willing to sacrifice civil liberties in exchange for improved public health conditions (Alsan et al. 2020). In comparison with other liberal democracies, the Japanese government applied a lesser level of individual liberties restrictions despite the state of emergency declaration. So, to what extent did the successful decreasing number of new contaminations during each wave highlight citizens' compliance with the government policies?[22] Considering that a polarization between social groups, due to unequal impact of the epidemic (economic, social, health, etc.), alter the social acceptance of restrictive measures, the national government's application of a significant economic programme to support the voluntary lockdown might also have positively influenced citizens' compliance. Nevertheless, the effectiveness of the coordination between political and economic actors and citizens is challenged by the long duration of the epidemic and its socio-economic consequences, bearing also mental and physical health degradation.

[22] Cato S, Iida T, Ishida K, McElwain KM, Shoji M (2020) Social distancing as a public good under the COVID-19 pandemic, Public Health, 188, 51–53; Kenneth Mori McElwain, "Who Trusts the Government to Handle COVID-19? Evidence from Panel Surveys in Japan", Lunch Seminar on Japanese Economy and Society organized by the IFRJ-MFJ, May 21, 2021. www.mfj.gr.jp/agenda/2021/05/21/mcelwain/.

3.3 The Third Wave (Mid-October to Early January): A New Paradigm?

At the end of September, following the two epidemic waves and with the aim of launching the “Go to” campaign throughout the country, the national government focused efforts on entertainment districts by dedicating working groups composed of experts, professional and regional public organizations on risk behavior and social dynamics analysis. Those working groups produced an increasingly precise level of knowledge about the "collective logic of discrimination", which is a crucial barrier for people to be tested.[23]

At the end of October, an increase in new cases of contamination was first observed in the northern regions and in Okinawa. This trend highlighted and brought to the knowledge of public authorities by the advisory sub commission could be explained by the high level of contamination in the entertainment districts of large cities such as Minami Osaka, Sukino Sapporo, Kabukicho Shinjuku, Sakae Nagoya, Nakasu Fukuoka, combined with inter-regional travels increase.[24] Clusters among young people, foreign communities, and asymptomatic were difficult to target using standard communication tools (press, media) and public authorities communication campaign. Therefore, following the second wave experience, coordinated measures at the community level between NGOs and local public authorities were deployed. Mid-November, several members of the experts’ sub commission stressed the need to implement measures at the national level supported by more targetted and educational risk communication. Three crisis factors were then mentioned by experts: the lack of effective communication and the difficulty to access high-risk groups; the increase of clusters difficult to identify (people with asymptomatic or weak symptoms); the delicate and difficult balance between the application of measures to prevent the spread of the virus and the support of economic activities. Thus, experts of the sub commission published the following recommendations to the public authorities early at the start of the third wave: limitation of the business hours for restaurants and bars for three weeks, suspending the “Go to travel” and “Go to eat” campaigns, shifting the calendar of end-of-year and early-year vacations, strengthening capacities of the surveillance system, health centres, and health facilities; encouraging changes in people’s behaviour (work, going out, daily life). At the end of December, in response to the spike of the epidemic, experts stressed the urgent need for strong leadership from both local and national government.[25]

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[23] Working group, September 29, 2020 https://www.cas.go.jp/jp/seisaku/ful/kanrakugai_wg_2.pdf; Working group, October 13, 2020 https://www.cas.go.jp/jp/seisaku/ful/kanrakugai_wg_3_gaiyou.pdf; Working group, October 27, 2020 https://www.cas.go.jp/jp/seisaku/ful/kanrakugai_wg_4_gaiyou.pdf.

[24] Advisory Board, October 28, 2020, 12th committee) https://www.mhlw.go.jp/content/10900000/000688923.pdf; Experts sub commission, October 29, 2020, 13th committee, https://www.cas.go.jp/jp/seisaku/ful/bunkakai/corona13.pdf.

[25] Advisory board, December 22, 2020, 19th committee, https://www.mhlw.go.jp/content/10900000/000709103.pdf; Experts Sub commission, December 23, 2020,19th committee, https://www.cas.go.jp/jp/seisaku/ful/bunkakai/corona19.pdf.

The second declaration of the state of emergency on January 7, 2021, reveals an apparent lack of multi-level coordination and a delayed application of experts' recommendations. The gap between the temporality of the epidemic and national government actions might have altered citizens' risk perception, recalling the first wave mechanisms. The revision of the Special Measures Act on New Influenza to introduce sanctions for non-compliance with government measures, such as closing restaurants from 8 p.m., transforms the principle of voluntary restraints into a coercive measure. This marks a turning point in Japanese COVID-19 political crisis management. Incorporating a legal constraint reveals a paradigm shift in crisis management that might highlight the government's weak political leadership.

3.3.1 The Third Wave Socio-Spatial Analysis

Mapping the third wave shows some changes in the types of localities in which the virus is spreading. Previous waves had a concentric pattern centred on the city centres and upper classes residential districts. The dynamics of the third wave change this pattern both nationally and regionally (see Fig. 5).

The highest growth rates in the per capita ratio were in the outlying prefectures of the archipelago: Kôchi, Akita, Tottori, and Iwate (the last prefecture contaminated by the virus in July). The most urban prefectures were thus the least affected by the acceleration of the epidemic if we consider the period from November 10 to December 15, but also December to January (Fig. 5). These prefectures had exceptionally low rates showing a kind of regularization (Fig. 6). However, the situation changed between November and January, contamination rates decreased in prefectures where it had increased sharply during the first part of the third wave: Akita, Kochi, Hiroshima, or Iwate. During the third wave suburbs had the highest growth rates in the per capita ratio (up to 1000%), while megacities situation did not improve, with already higher rates in the per capita ratio, and with a steady raising number of cases (200% for Tokyo). The most affected prefectures remain the same, while the dynamics were different. The epidemic was spreading to the periphery, both nationally and regionally, as can be seen in the greater Tokyo area where the prefectures of Chiba, Saitama, and Kanagawa had a stronger evolution of their prevalence rate.

In this context, the "Go to" campaign, which promoted local tourism with subsidies for accommodation, restaurants, and shopping from July 22, and from October 1 for the inhabitants of Tokyo, was debated as being a factor of the third wave epidemic dynamic. In the face of increased contamination in the outlying territories, the programme was abruptly suspended on December 15.

The epidemic continued to progress in the central districts but at a much slower rate than in the municipalities on the outskirts, in the west of Tokyo and in Saitama (Fig. 7). While prevalence rate increased by more than 100% in some areas, the district of Shinjuku had less than 30% increase between November and December. Thus, the virus circulated more actively in residential areas and affected diverse type of populations within different structures (for example, households, nurseries, hospitals, elderly care institutions, workplaces).

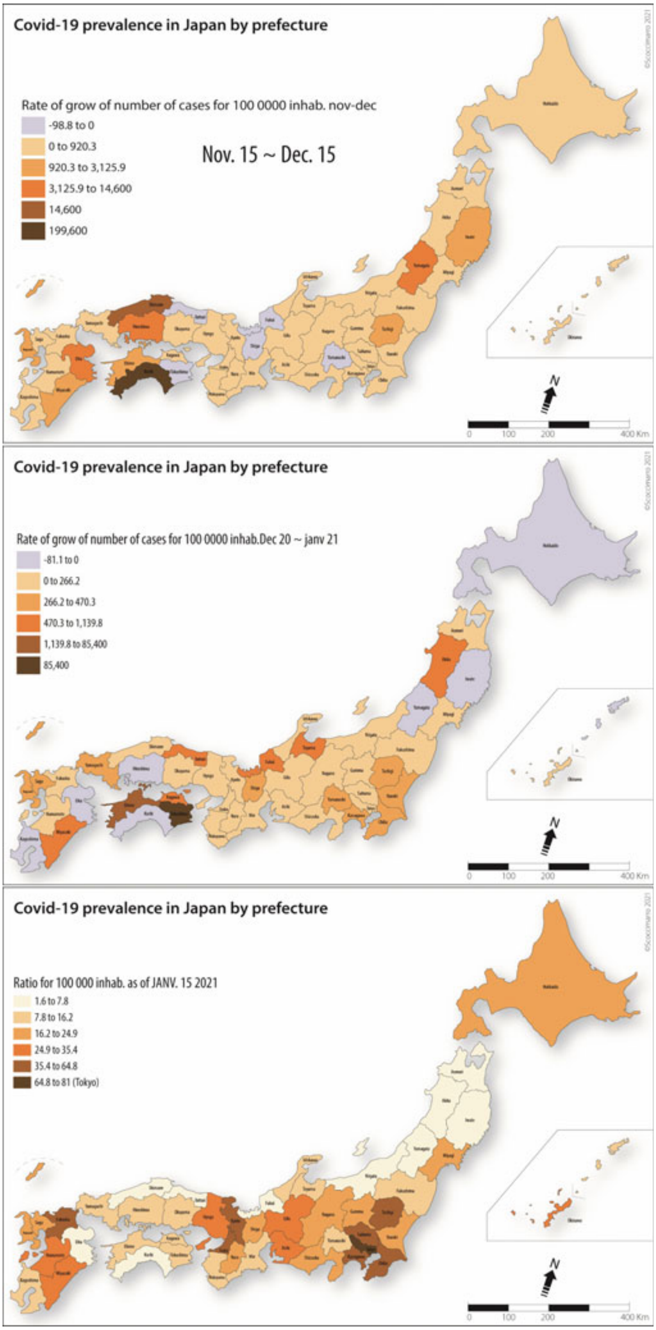

Fig. 5 Evolution of COVID-19 epidemic by prefecture from November 10 to January 15

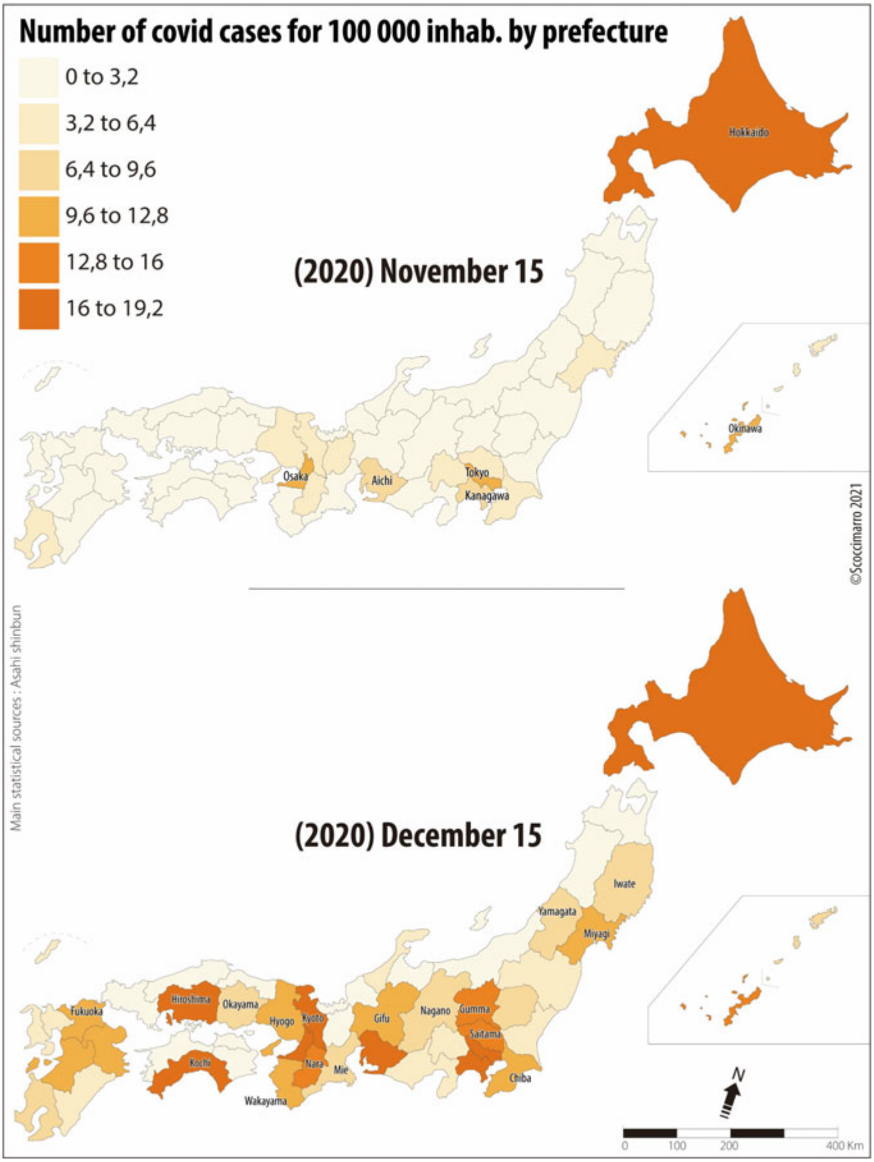

Fig. 6 Comparison of COVID-19 prevalence by prefecture between November 15 and December 15

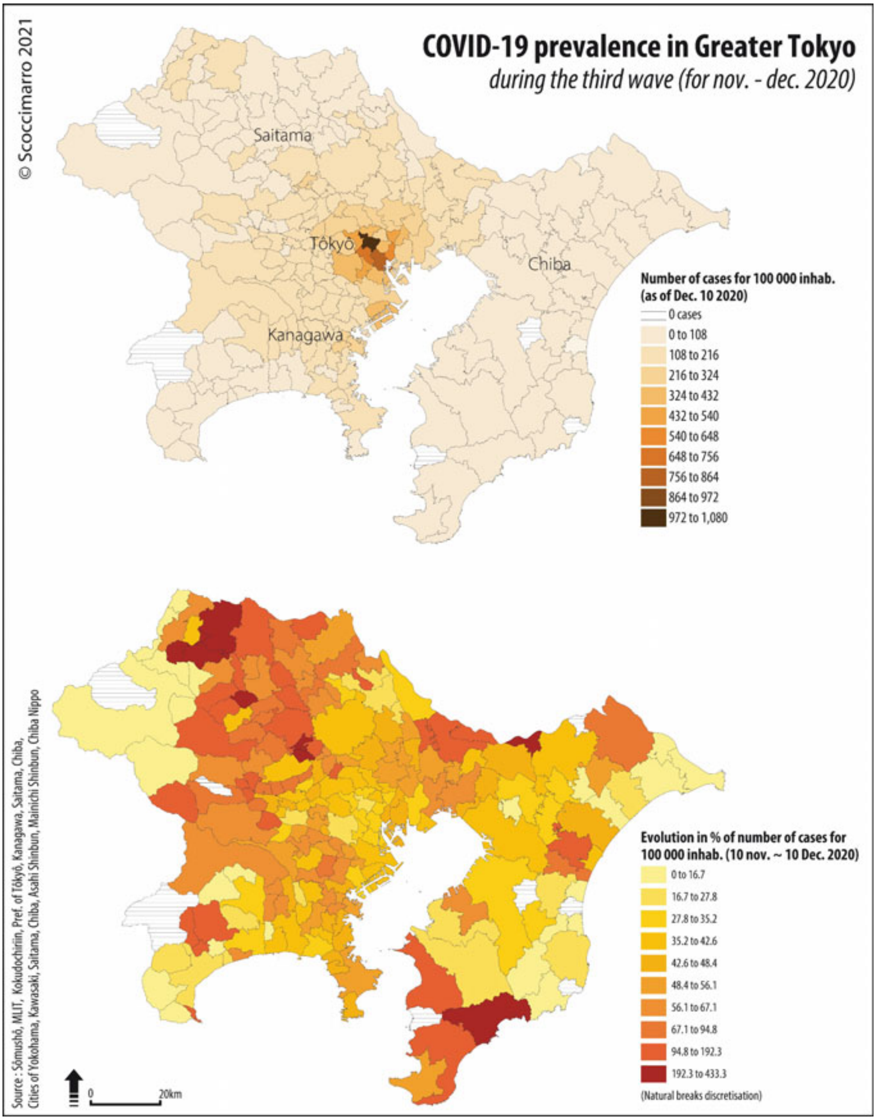

Fig. 7 Evolution of COVID-19 prevalence by municipality in Greater Tokyo Area from November 10 to December 10

As shown in Fig. 8, despite higher and rapid growth of prevalence rates in suburban municipalities from December to January (up to +191.4% in Akiruno city, +37% only for Shinjuku ward) this rate was rather low compared to central districts such as Shibuya (1050 cases for 100,000 inhabitants), Minato (1163 cases for 100,000 inhabitants), and Shinjuku (1480 cases for 100,000 inhabitants). Therefore, the overall Japanese spatial distribution of COVID-19 cases was not modified by the third wave.

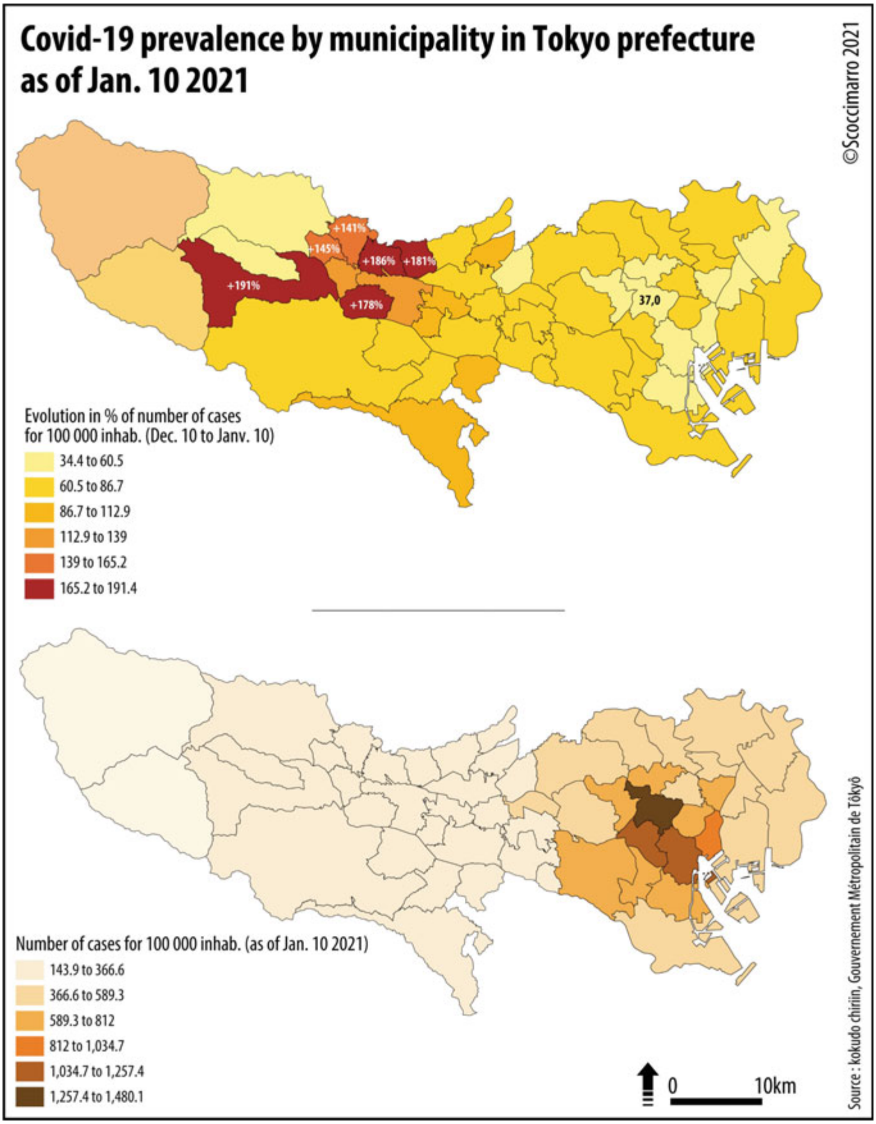

Fig. 8 Evolution of COVID-19 prevalence by municipality (ku-shi-chô-son) in Tokyo prefecture from November 10 to December 10

4 Conclusion

The low mortality rate until the end of August reflected a relatively effective management of the current epidemic by international comparison. However, it is difficult to define a Japanese model, especially since local situations are remarkably diverse due to the great leeway of the prefectures, headed by governors who have broad prerogatives. The local authorities seem to have been the most effective and responsive in the epidemic management, hence sometimes generating confrontation with the national government. Social control and some form of regulation through fear reinforced by social discrimination are powerful levers that arouse social criticism but can lead to the application of preventive measures recommended by the authorities.

Thus, Japan was applying partial but sustainable lockdown supported by a major economic recovery plan. Social acceptance and civic responsibility allow for continuity in coordination with the other two pillars. However, the third wave challenged this equilibrium. If local authorities managed the second wave rather well, the third wave seemed more difficult to control. First of all, the expansion of the epidemic showed a general increase in prevalence, especially in the outlying territories. The "Go to" campaigns might have blurred the sense of urgency and might have played a role in the spread of the epidemic to prefectures far from urban centres, and the increase in prevalence in suburban municipalities. The counter-measures that had worked well in the summer appear to be less suited to these territories. However, the return of the state of emergency and the closure of restaurants and bars from 8 p.m. finally lowered the spread of the virus in the mid-term since there was a decrease in daily cases at the national level from January 10. At the end of February, the level of daily cases was brought back to the level of November.

References

Alsan M, Braghieri L, Eichmeyer S, Kim MJ, Stantcheva S, Yang DY (2020) Civil liberties in Times of Crisis NBER working paper 27972

Beck U (1992) Risk society: towards a new modernity (Trans. by Ritter M). Sage Publications, London

Benini Aldo A (1999) Network without Centre? A case study of an organizational network responding to an earthquake. J Contingencies Crisis Manag 7(1):38–47

Bergeron H, Borraz O, Castel P, Dedieu F (2020) Covid-19: une crise organisationnelle. Presses de Sciences Po, Paris

Berlivet L (2004) Une biopolitique de l'éducation pour la santé. La fabrique des campagnes de prévention. In: Fassin D, Memmi D (eds) Le Gouvernement des corps. Éditions de l'EHESS, Paris, pp 37–74

Boin A, Hart P (2003) Public leadership in Times of Crisis. Public Adm Rev 63(5):544–553

Borraz O (2021) Olivier Borraz on the Covid-19 Pandemic, interview. SASE, 23 February 2021. https://sase.org/news/pandemic-dossier/olivier-borraz-on-the-covid-19-pandemic/. Last visited on 4 March 2021

Borraz O, Gimbert V, Torny D (2007) Regards sur la sécurité sanitaire en France. Horizons Stratégiques 1(1):63–79

Burgess A, Mitsutoshi H (2012) Risk, ritual and health responsibilisation: Japan's "safety blanket" of surgical face mask-wearing. Sociol Health Illness 34(8)

Coombs WT (2015) Ongoing crisis communication: planning, managing, and responding, 4th edn. Sage, Thousand Oaks, CA

Dore R (1990) Japan: a nation made for corporatism? In: Crouch C, Dore R (eds) Corporatism and accountability: organized interests in British public life. Clarendon, Oxford, pp 45–62

Foucault M (2004) Naissance de la biopolitique. Cours au Collège de France 1978–1979. Gallimard, Paris

Levay C (2009) Technologies of self as a means of translation in an obesity intervention. In: Paper presented at the CSO-CNRS-Sciences Po, p 33

Nomura T, Takahashi H, Takeda Y (2003) Changes in measures against infectious disease in Japan and proposals for the future. J Japan Med Assoc 46(9):390–400

Oshitani H, Experts Members of The National COVID-19 Cluster Taskforce at Ministry of Health, Labour and Welfare, Japan (2020) Cluster-based approach to Coronavirus Disease 2019 (COVID-19) response in Japan-February–April 2020. Jpn J Infect Dis

Sala A (2020) Le Japon face à l'épidémie. Gestion de crise et responsabilité civique, La Vie des idées, ISSN 2105-3030. https://laviedesidees.fr/Le-Japon-face-a-l-epidemie.html

Shingata korona taiyô—minkan rinjichôsakai, chôsa-kenshô hôkokusho, ippandantaihôjin azia—pashifiku-inishiatibu, October 2020 (Novel coronavirus counter measures—civil society special survey, investigation report, Initiative Asia-Pacific, October 2020)

Taniguchi K, Shigematsu M, Yasui Y, Tada Y et al (2007) Overview of infectious disease surveillance system in Japan, 1999–2005. J Epidemiol 17

Tashiro A, Shaw R (2020) COVID-19 pandemic response in Japan: what is behind the initial flattening of the curve? Sustainability 12(13):5250

't Hart P, Rosenthal U, Kouzmin A (1993) Crisis decisionmaking: the centralization thesis revisited. Adm Soc 25(1):12–41

Ueda M, Matsubayashi T, Nordström R (2020) Suicide and mental health during the Covid-19 pandemic in Japan. medRxiv 2020.10.06.20207530

Umeda S (2015) Japan legal responses to health emergencies. Library of Congress www.loc.gov/law/help/health-emergencies/japan.php#_ftnref77. Last visited on 30 January 2021

Sakamoto H et al (2018) Japan health system review. Health Syst Trans 8(12018)

Yamamoto T, Uchiumi C, Suzuki N, Yoshimoto J, Murillo-Rodriguez E (2020) The psychological impact of 'mild lockdown' in Japan during the COVID-19 pandemic: a nationwide survey under a declared state of emergency. Int J Environ Res Public Health. https://doi.org/10.3390/ijerph17249382

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Chapter 6
Application of SARS-CoV-2 Serology Testing: A Case Study

Masaki Yamamoto, Yasufumi Matsumura, and Miki Nagao

Abstract Coronavirus disease 2019 (COVID-19) caused by the new coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) emerged in early December 2019, in Wuhan city, the capital city of Hubei Province. This virus spread easily and rapidly worldwide. A lot of serology testing for COVID-19 are now available, and very powerful tools to understand the immune response to SARS-CoV-2, vaccine efficacy, hard immunity among communities, and so on. However, there remains several uncertainties about serology testing, compared to the direct virus detection test, such as reverse transcription polymerase chain reaction (RT-PCR) and antigen test. In this chapter, we introduce the current understanding of serological testing for COVID-19 to clarify how to use and select during the COVID-19 pandemic.

Keywords Sars-Cov-2 · Serology testing · COVID-19 pandemic

1 What is SARS-CoV-2 Serology Testing?

Diagnostic modalities for COVID-19 infection used in clinical settings include the nucleic acid amplification test (NAAT), antigen testing, and serology testing. Serology testing, also known as antibody testing, is usually conducted after complete recovery from COVID-19. While serological immunoassays are now widely available from many diagnostic manufacturers globally, there is significant debate regarding their clinical utility, as well as the appropriate clinical and analytical performance characteristics for routine applications during the current pandemic.

To date, there have been few guidelines or statements regarding serological testing. Serological testing has been used to confirm the prevalence of COVID-19 infection in certain cohorts, such as communities or healthcare professionals.

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In addition, serological testing can be used for the following purposes:[1,2]

- to quantitatively evaluate the antibody response in COVID-19 patients;
- to assist in identifying potential convalescent plasma donors;
- to assist in identifying immunity and evaluating the antibody response to vaccines;
- to assist in monitoring the progression of herd immunity.

As such, serological testing offers marked potential to understand COVID-19. However, just like for NAAT, each serological test exhibits different sensitivity and specificity among each testing method, and the antigen used for detection in each assay differs, which will consequently affect the sensitivity and specificity as well.

In this chapter, we briefly describe the type and selection of serological testing and a case study involving a cohort of essential workers in Kyoto city.

2 Antibody Testing for COVID-19: Types and Selection

The diagnosis of COVID-19 is mainly based on viral nucleic acid detection, such as by the reverse transcription-polymerase chain reaction (RT-PCR). Although RT-PCR assays generally have high sensitivity (71–98%), false-negative results can occur due to inappropriate sample collection.[3] Furthermore, more than 80% of people infected with COVID-19, especially young people, are known to be asymptomatic or have mild disease. It is difficult to diagnose such people with COVID-19. Therefore, it is problematic to clarify the actual prevalence of COVID-19 using direct detection methods.

If pathogenic microorganisms, including SARS-CoV-2, infect humans, immune responses occur in the body. In this process, the production of specific antibodies (immunoglobulins) by the host's plasma B cells on encountering the pathogens comprises one of the most important immune responses. These responses can occur even if the person has no obvious symptoms of infection (for example, fever, cough, and shortness of breath). Antibody tests, also known as serology tests, detect the host's immune response to the infection rather than detecting the virus itself. Antibody tests are used to detect specific antibodies in human blood and are considered as important methods in epidemiological research and to monitor seropositivity. Moreover, a serology test can provide information on the immune status after vaccination, and could help determine appropriate donors of convalescent plasma.

For example, in the guidelines of the Centers for Disease Control and Prevention (CDC) in America, the antibody test has been designed and validated for surveillance and research purposes. Its purpose is to estimate the percentage of the population

[1] Bohn et al. (2020).

[2] Interim Guidelines for COVID-19 Antibody Testing.

[3] The Infectious Diseases Society of America Guidelines on the Diagnosis of COVID-19: Molecular Diagnostic Testing.

previously infected with SARS-CoV-2, which is necessary to guide the response to the pandemic and protect the public's health.[4]

2.1 CDC Guidelines and EUA of Antibody Testing by FDA

The CDC summarized antibody tests for COVID-19 in their "Interim Guidelines for COVID-19 Antibody Testing", as follows[5]:

- Several serologic assays for SARS-CoV-2 have received Emergency Use Authorization (EUA) by the US Food and Drug Administration (FDA), which has independently reviewed their performance.
- Currently, there is no known advantage of assays testing for IgG, IgM, IgG, or total antibody.
- It is important to minimize false-positive test results by choosing an assay with high specificity and by testing populations and individuals with an elevated likelihood of previous exposure to SARS-CoV-2. Alternatively, an orthogonal testing algorithm (that is, employing two independent tests in sequence when the first test yields a positive result) can be used when the expected positive predictive value of a single test is low.
- Antibodies most commonly become detectable 1–3 weeks after symptom onset, at which time evidence suggests that infectiousness markedly decreases and some degree of immunity from future infection has developed. However, additional data are needed before revising public health recommendations based on serologic test results, including decisions on discontinuing physical distancing and using personal protective equipment.

At the end of December 2020, many antibody tests for COVID-19 had been made available and approved by the FDA under EUA.[6] (Table 1) These tests show high sensitivity and specificity. However, the sensitivity of LFAs is relatively low compared with other laboratory assays, such as ELISA and other high-throughput assays. According to the "Interim Guidelines for COVID-19 Antibody Testing" by the CDC, antibody tests with sufficiently high specificity (for example, > 99.5%) are required to ensure a high positive predictive value (for example, 95%). Therefore, ELISA and other high-throughput assays are more appropriate than LFAs for seroprevalence surveillance.

[4] Interim Guidelines for COVID-19 Antibody Testing.

[5] Interim Guidelines for COVID-19 Antibody Testing.

[6] EUA Authorized Serology Test Performance.

Table 1 Antibody testing approved by FDA under EUA

Assay	Developer	Method	Target	Immunoglobulin class	Sensitivity (95% CI)	Specificity (95% CI)	PPV* (95% CI)	NPV** (95% CI)
Point-of-care testing								
WANTAI SARS-CoV-2 Ab Rapid Test	Beijing Wantai	LFA	Spike	Pan-Ig	100.0% (88.7–100)	98.8% (93.3–99.8)	80.8% (40.9–96.0)	100.0% (99.4–100)
Innovita 2019-nCoV Ab Test (Colloidal Gold)	Innovita Biological Technology	LFA	Spike & Nucleocapsid	IgM	93.3% (78.7–98.2)	98.8% (93.3–99.8)		
				IgG	93.3% (78.7–98.2)	98.8% (93.3–99.8)		
				Combined	100% (88.7–100)	97.5% (91.3–99.3)	67.8% (35.0–88.4)	100% (99.4–100)
High throughput assays								
Access SARS-CoV-2 IgG	Beckman Coulter	CLIA	Spike	IgG	96.8% (91.1–98.9)	99.6% (99.2–99.8)	93.5% (85.2–97.2)	99.8% (99.5–99.9)
Access SARS-CoV-2 IgM	Beckman Coulter	CLIA	Spike	IgM	96.7% (92.5–98.6)	99.9% (99.5–100)	97.3% (90.4–99.3)	99.8% (99.6–99.9)
LIAISON SARS-CoV-2 IgM Assay	DiaSorin	CLIA	Spike	IgM	91.8% (85.6–95.5)	99.3% (98.9–99.5)	86.9% (79.7–91.6)	99.6% (99.2–99.8)
LIAISON SARS-CoV-2 S1/S2 IgG	DiaSorin	CLIA	Spike	IgG	97.6% (87.4–99.6)	99.3% (98.6–99.6)	87.5% (76.1–93.4)	99.9% (99.3–100)

(continued)

Table 1 (continued)

Assay	Developer	Method	Target	Immunoglobulin class	Sensitivity (95% CI)	Specificity (95% CI)	PPV* (95% CI)	NPV** (95% CI)
VITROS Anti-SARS-CoV-2 IgG test	Ortho-Clinical Diagnostics	CLIA	Spike	CLIA	90.0% (76.9–96.0)	100% (99.1–100)	100% (81.2–100)	99.5% (98.8–99.8)
VITROS Immunodiagnostic Products Anti-SARS-CoV-2 Total Reagent	Ortho-Clinical Diagnostics	CLIA	Spike	Pan-Ig	100% (92.7–100)	100% (99.0–100)	100% (83.7.-100)	100% (99.6–100)
ADVIA Centaur SARS-CoV-2 IgG (COV2G)	Siemens Healthcare Diagnostics	CLIA	Spike	IgG	100% (91.6–100)	99.9% (99.6–99.9)	98.0% (92.4–99.4)	100% (99.6–100)
Atellica IM SARS-CoV-2 IgG (COV2G)	Siemens Healthcare Diagnostics	CLIA	Spike	IgG	100% (91.6–100)	99.9% (99.7–100)	99.0% (94.0–99.8)	100% (99.6–100)
ADVIA Centaur SARS-CoV-2 Total (COV2T)	Siemens Healthcare Diagnostics	CLIA	Spike	Pan-Ig	100% (92.4–100)	99.8% (99.4–99.9)	96.5% (89.8–98.8)	100% (99.6–100)
Atellica IM SARS-CoV-2 Total (COV2T)	Siemens Healthcare Diagnostics	CLIA	Spike	Pan-Ig	100% (91.6–100)	99.8% (99.3–99.9)	96.6% (87.9–99.1)	100% (99.6–100)
Alinity i SARS-CoV-2 IgG	Abbott	CMIA	Nucleocapsid	IgG	100% (89.9–100)	99.0% (94.6–99.8)	84.0% (46.5–96.8)	100% (99.4–100)
Architect SARS-CoV-2 IgG	Abbott	CMIA	Nucleocapsid	IgG	100% (95.8–100)	99.6% (99.0–99.9)	93.4% (84.0–97.3)	100% (99.8–100)

(continued)

Table 1 (continued)

Assay	Developer	Method	Target	Immunoglobulin class	Sensitivity (95% CI)	Specificity (95% CI)	PPV* (95% CI)	NPV** (95% CI)
Laboratories AdviseDx SARS-CoV-2 IgM (Alinity i)	Abbott	CMIA	Spike	IgM	95.0% (83.5–98.6)	99.6% (99.3–99.7)	92.0% (85.5–95.3)	99.7% (99.1–99.9)
Laboratories AdviseDx SARS-CoV-2 IgM (Architect)	Abbott	CMIA	Spike	IgM	95.0% (83.5–98.6)	99.6% (99.3–99.7)	91.9% (85.4–95.3)	99.7% (99.1–99.9)
Elecsys Anti-SARS-CoV-2	Roche	ECLIA	Nucleocapsid	Pan-Ig	100% (88.3–100)	99.8% (99.7–99.9)	96.5% (93.0–98.1)	100% (99.4–100)
Elecsys Anti-SARS-CoV-2 S	Roche	ECLIA	Spike	Pan-Ig	96.6% (93.4–98.3)	100% (99.9–100)	99.7% (98.1–99.9)	99.8% (99.7–99.9)
VIDAS SARS-CoV-2 IgG	bioMérieux	ELFA	Spike	IgG	100% (88.3–100)	99.9% (99.4–100)	98.1% (89.1–99.7)	100% (99.4–100)
VIDAS SARS-CoV-2 IgM	bioMérieux	ELFA	Spike	IgM	100% (85.7–100)	99.4% (97.7–99.8)	89.0% (65.9–96.7)	100% (99.2–100)
WANTAI SARS-CoV-2 Ab ELISA	Beijing Wantai	ELISA	Spike	Pan-Ig	96.7% (83.3–99.4)	97.5% (91.3–99.3)	67.1% (33.6–88.4)	99.8% (99.0–100)
Platelia SARS-CoV-2 Total Ab	Bio-Rad Laboratories	ELISA	Nucleocapsid	Pan-Ig	98.0% (89.5–99.6)	99.3% (98.3–99.7)	88.6% (73.5–95.3)	99.9% (99.4–100)
SARS-COV-2 ELISA (IgG)	EUROIMMUN	ELISA	Spike	IgG	90.0% (74.4–96.5)	100% (95.4–100)	100% (46.1–100)	99.5% (98.6–99.8)

(continued)

Table 1 (continued)

Assay	Developer	Method	Target	Immunoglobulin class	Sensitivity (95% CI)	Specificity (95% CI)	PPV* (95% CI)	NPV** (95% CI)
cPass SARS-CoV-2 Neutralization Antibody Detection Kit	GenScript USA	ELISA	Spike	Pan-Ig (Neutralizing)	100% (87.1–100)	100% (95.8–100)	100% (52.3–100)	100% (99.3–100)

* PPV indicates positive predictive value at prevalence 5%

** NPV indecates negative predictive value at prevalence 5%

Abbreviations: FDA, U.S. Food and Drug Administration; EUA, emergency use authorization; LFA, lateral flow assay; CMIA, chemiluminescent Microparticle Immunoassay; CLIA, chemiluminescent immunoassay; ECLIA, electro-chemiluminescent immunoassay; EFLA, enzyme-linked fluorescent assay; ELISA, enzyme-linked immunosorbent assay

Table 2 Characteristics of antibody testing

Test procedure	High-throughput	time-to-result	Sensitivity	Specificity
Most simple	No	10–30 min	Relatively low	High
Complicate	Yes	2–5 h	High	High
Simple	Yes	1–2 h	Highest	High
Most complicate	No	3–5 days	–	–

Abbreviations: LFA, lateral flow assay; CLIA, chemiluminescent immunoassay; ELISA, enzyme-linked immunosorbent assay

2.2 *Types of Antibody Testing*

Antibody tests for COVID-19 are markedly diverse in terms of test methods, target proteins, and immunoglobulin classes they detect (Table 1). Actually, multiple different types of assays are available to detect different aspects of the immune response and functionality of antibodies. Test methods vary widely, including: the lateral flow assay (LFA), which is often used for point-of-care testing, enzyme-linked immunosorbent assay (ELISA), and other automated high-throughput assays, such as the electro-chemiluminescent immunoassay (ECLIA), chemiluminescent immunoassay (CLIA), and chemiluminescent microparticle immunoassay (CMIA).[7] These assays mainly use spike protein, nucleocapsid protein, or their combination as target protein. The spike protein of SARS-CoV-2, which plays an important role in fusion and entry into the host cell, consists of an S1 domain that contains the receptor-binding domain (RBD) and S2 domain. The nucleocapsid protein of SARS-CoV-2 has a role in binding and packing of the viral RNA genome into a helical nucleocapsid structure during viral replication. These tests are divided into two categories to detect either binding (binding antibody detection) or neutralizing (neutralizing antibody detection) antibodies. The characteristics of each assay are summarized in Table 2.[8]

2.2.1 Binding Antibody Detection

Lateral flow assays (LFAs) are widely used in human health for point-of-care testing (POCT) because of their convenience and ease of use. LFAs can be performed by a healthcare professional or by the patient in some instances, and in a range of settings, such as a hospital laboratory, clinic, or home. Sample preparation is very simple, and it only takes about 10–30 min to obtain the results. Typical LFAs use a test strip and require a drop of whole blood, plasma, or serum to detect the presence of immunoglobulins (for example, IgA, IgG, or IgM) against SARS-CoV-2 antigen.

[7] Ghaffari et al. (2020).

[8] Bastos et al. (2020).

Although some LFAs need a specific instrument for each assay to measure the results, they are generally judged visually.

The ELISA assay, currently one of the most commonly used assays for antibody testing, is a laboratory-based test with an average time-to-result of 2–5 h. ELISA typically uses a plate whose surface of each well is coated with a specific antigen to bind to and detect the corresponding host immunoglobulins (for example, IgA, IgG, or IgM) in whole blood, plasma, or serum samples. Then, the antigen–antibody complex is detected by a second antibody and a colorimetric or fluorescent substrate.

Other assays are usually performed using automated clinical laboratory equipment, and many samples are analyzed simultaneously. For example, the CLIA assay is similar to ELISA in that it takes advantage of high binding affinity between antigens and host antibodies but uses chemical probes that emit light through a chemical reaction to generate a positive signal. CLIA has a shorter average time-to-result (1–2 h).[9]

CLIA and ELISA are both high-throughput laboratory-based assays with high concordance.[10]

Surrogate virus neutralization tests (sVNT) are another type of binding antibody detection test. These assays are aimed to detect potential neutralizing antibodies that inhibit the interaction between RBD and angiotensin-converting enzyme 2 (ACE2, the cell receptor responsible for mediating infection by SARS-CoV-2).

These assays can be performed in BSL-2 laboratories.

2.2.2 Neutralizing Antibody Detection

The neutralizing antibody detection assay (neutralization assay) is a laboratory-based test that uses live virus and cell culture methods to determine if patient antibodies can prevent viral infection in vitro. The test procedures are laborious and must be performed in laboratories with designated biosafety certificates (for example, BSL-3) to culture SARS-CoV-2-infected cells and has a time-to-result of 3–5 days.[11]

[9] Ghaffari et al. (2020).

[10] Vashist (2020).

[11] Ghaffari et al. (2020).

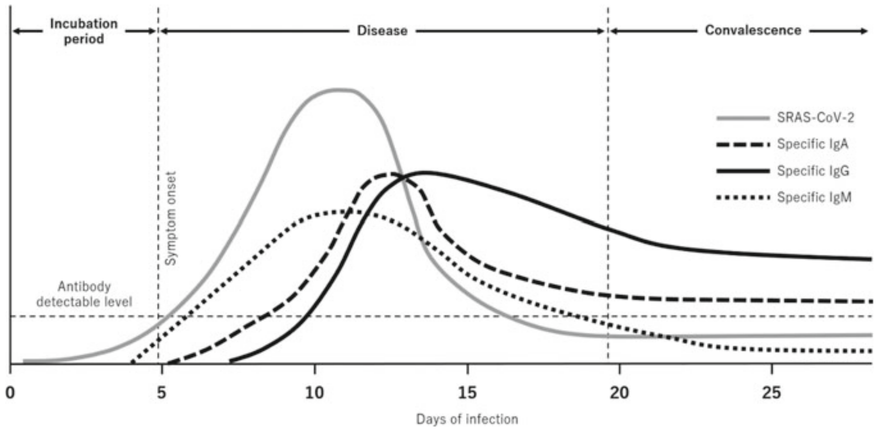

Fig. 1 Dynamics of seroconversion in COVID-19 patients[12]

2.3 *Dynamics of Seroconversion in COVID-19 Patients*

The timelines for the SARS-CoV-2 viral load and dynamics of IgA, IgG, and IgM are shown in Fig. 1.[13] Antibodies are not detectable in the early phase of COVID-19 infection, but they can be detected after viral load increase.

Figure 2 shows the seropositive rate from symptom onset among COVID-19 patients. The results of two total antibody assays (A_Ab and C_Ab), two IgG assays (B_IgG and C_IgG), and two IgM assays (B_IgM and C_IgM) were evaluated, using 269 serum samples from 27 hospitalized patients at Kyoto University Hospital, Kyoto, Japan. The positive rate of antibody testing gradually rises until 15 days from symptom onset. The positive rate of pan-immunoglobulin assays is high and similar to that of IgG assays, and these are higher than that of IgM assays. As described in previous studies,[14] the positive rate is relatively low in the early stage of COVID-19, because the host's immune response remains insufficiently established. Therefore, antibody testing may be less effective in this period. There are no clear data on how long the antibodies for SARS-CoV-2 are detectable. IgG could be detectable at least 49 days after symptom onset.[15] On the other hand, IgM might not be detectable beyond 30 days after onset.

[12] Wölfel et al. (2020).

[13] Ghaffari et al. (2020).

[14] Wölfel et al. (2020).

[15] Zhang et al. (2020).

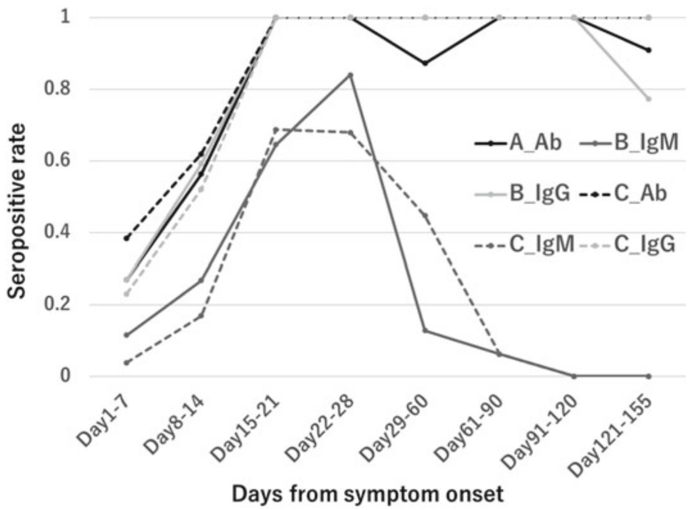

Fig. 2 Seropositive rate from symptom onset Pan-Ig assay: company A total antibody assay (A_Ab), company C total Ab assay (C_Ab) IgM assay: company B IgM assay (B_IgM), company C IgM assay (C_IgM) IgG assay: company B IgG assay (B_IgG), company C IgG assay (C_IgG)

2.4 Antibody Test Selection

To use antibody tests appropriately and effectively, it is important to comprehensively understand their performance characteristics and limitations. At present, antibody testing can be used most effectively for seroprevalence surveillance. The use of antibody tests to diagnose COVID-19 infection and evaluate vaccine immunity or convalescent serum is still controversial and requires further evaluation. When antibody tests are used in clinical settings, those with a high sensitivity of greater than 99.5% should be chosen, especially in areas with a low prevalence of COVID-19.

Moreover, the tests should be repeated if necessary. The results of a single antibody test are not sufficiently accurate in low-prevalence populations.[16] Thus, in these situations, a single test is rarely used to make a decision on whether a person has been infected previously or truly has specific antibodies to the virus. A second test that detects the presence of antibodies to a different viral protein would generally be needed to increase the accuracy of the overall test results. One concern regarding antibody testing should be noted: COVID-19 patients who are asymptomatic or with mild disease might have a lower immune response than patients with severe disease, and immunoglobulins could decline to undetectable levels throughout the course of infection. Therefore, well-designed research is needed, such as seroprevalence surveillance repeated every two or three months in the same study population.

[16] Interim Guidelines for COVID-19 Antibody Testing.

3 Epidemiological Study of COVID-19

The novel coronavirus, SARS-CoV-2 infection (COVID-19), was first reported from China at the end of 2019. This virus has spread very rapidly, and the resulting pandemic remains an international public health emergency. Data on how many people have been infected comprise one of the most important epidemiological factors influencing public health policies. To date, many studies have been reported on national or local seroprevalence surveillance. During the present global pandemic of COVID-19, national surveillance data play a critical role in combatting and controlling the COVID-19 outbreak. In addition, local epidemiological data also play a key role, because local administrations should manage infection control in each outbreak area. Therefore, we perform seroprevalence surveillance in Kyoto city.

3.1 Previous Study on Seroprevalence of COVID-19

Seroprevalence surveillances of COVID-19 have been conducted all over the world, and several examples are presented as follows:

In the US, nationwide repeated cross-sectional seroprevalence research was conducted using a total of 177,919 serum samples from all 50 states between July and September 2020,[17] although about 7.2 million people had been reported to be infected at the end of September 2020. Commercially available high-throughput IgG assays, all of which have high specificity, were used, including the Abbott ARCHITECT assay, Ortho-Clinical Diagnostics VITROS assay, and Roche Elecsys assay. At that time, the overall prevalence of COVID-19 in the US was less than 10%, ranging from almost 0% (Alaska State) to over 20% (New York State). The outbreak of COVID-19 remains an existential threat in the US. Confirmed cases of COVID-19 have doubled since October 2020.[18] Therefore, a prevalence rate of 20% might be insufficient for herd immunity.

In the UK, seroprevalence was reported by Public Health England in October 2020.[19] This research was conducted using the Euroimmun ELISA assay and healthy blood donors. London was the most prevalent area (about 15%) in the UK, followed by the north west (10%), and east of England (8%).

In Germany, in early 2020, a seroprevalence of 0.91% was reported, using the Euroimmun ELISA assay.[20]

In Japan, the Ministry of Health, Labour and Welfare reported a COVID-19 seroprevalence of 0.038% in Tokyo, 0.02% in Osaka, and 0.004% in Miyagi Prefecture

[17] Bajema et al. (2020).

[18] COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU).

[19] Sero-surveillance of COVID-19.

[20] Fischer et al. (2020).

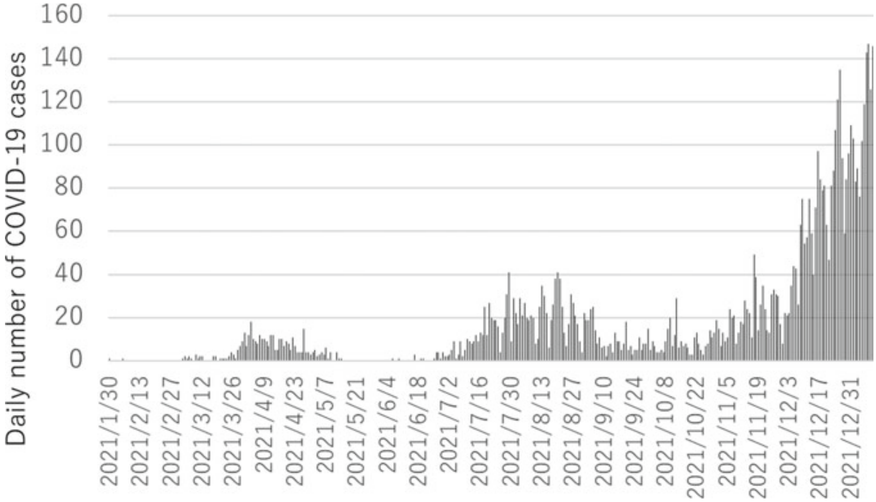

Fig. 3 Daily number of confirmed cases of COVID-19

in June 2020. The Abbott ARCHITECT assay and Roche Elecsys assay were used in this research.[21]

3.2 Prevalence Surveillance in Kyoto City

We started seroprevalence surveillance in Kyoto city from July 2020. The initial research was conducted between July and August 2020. Antibody testing was performed using the YHLO CLIA IgG and IgM kit, a high-throughput CLIA assay showing high-level concordance with the Roche Elecsys assay. In our research, the sensitivity and specificity of this IgG assay were 91.9% (95% confidence interval: 87.7–95.1) and 100% (95%CI: 96.4–100), respectively. Among the 1737 serum samples from healthcare workers and essential workers analyzed, only eight (0.46%) were seropositive for SARS-CoV-2.

As shown in Fig. 3, the daily number of confirmed cases of COVID-19 has been increasing since the end of October 2020.[22] This local surveillance should be continued to evaluate and estimate the actual prevalence of COVID-19 in this region.

Only a year has passed since we first encountered COVID-19. Throughout that year, we have been trying to understand what "it" is and how "it" behaves. Due to concerted efforts, various testing modalities can now be used in clinical settings. At the present point, we have reached the stage where we need to determine how

[21] Result of Serosurveillance, in Japanese.

[22] COVID-19 in Kyoto Prefecture.

to appropriately apply serology testing in order to control the COVID-19 pandemic through our case study in Kyoto city.

References

Bajema KL et al (2020) Estimated SARS-CoV-2 Seroprevalence in the US as of September 2020. JAMA Internal Medicine, 24 Nov 2020

Bastos ML et al (2020) Diagnostic accuracy of serological tests for covid-19: systematic review and meta-analysis. BMJ, 1 July 2020

Bohn MK et al (2020) IFCC Interim Guidelines on Serological Testing of Antibodies against SARS-CoV-2. Clin Chem Lab Med, 7 Oct 2020

COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU). https://coronavirus.jhu.edu/map.html

EUA Authorized Serology Test Performance. www.fda.gov/medical-devices/coronavirus-disease-2019-covid-19-emergency-use-authorizations-medical-devices/eua-authorized-serology-test-performance

Fischer B et al (2020) SARS-CoV-2 IgG seroprevalence in blood donors located in three different federal states, Germany, March to June 2020. Euro Surveill, 16 July 2020

Ghaffari A et al (2020) COVID-19 Serological Tests: How Well Do They Actually Perform?, 4 July 2020. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7400479/

Infectious Diseases Society of America Guidelines on the Diagnosis of COVID-19: Molecular Diagnostic Testing. www.idsociety.org/globalassets/idsa/practice-guidelines/covid-19/diagnostics/idsa-covid-19-gl-dx-v2.0.0.pdf

Interim Guidelines for COVID-19 Antibody Testing. www.cdc.gov/coronavirus/2019-ncov/lab/resources/antibody-tests-guidelines.html

Kyoto Prefecture. COVID-19 in Kyoto Prefecture, in Japanese. https://kyoto.stopcovid19.jp/

Ministry of Health, Labour and Welfare. Result of Serosurveillance, in Japanese. www.mhlw.go.jp/content/10906000/000640184.pdf

Public Health England. Sero-surveillance of COVID-19. www.gov.uk/government/publications/national-covid-19-surveillance-reports/sero-surveillance-of-covid-19

Vashist SK (2020) In Vitro diagnostic assays for COVID-19: Recent advances and emerging trends. Diagnostics, April 5

Wölfel R et al. (2020) Virological assessment of hospitalized patients with COVID-2019. Nature, December 11

Zhang J et al. (2020) Serological detection of 2019-nCoV respond to the epidemic: A useful complement to nucleic acid testing. medRxiv (preprint), March 10

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Part II
Socio-Life Scientific Data Building

Chapter 7
Cohort Profile: The Nagahama Prospective Genome Cohort for Comprehensive Human Bioscience (The Nagahama Study)

Kazuya Setoh and Fumihiko Matsuda

Abstract The Nagahama Prospective Cohort for Comprehensive Human Bioscience is the first large-scale multipurpose genome cohort in Japan. The project started in 2007 with a new concept of "pre-primary prevention" aiming to realize personalized early disease prevention based on the genetic background of each individual, detailed measurement of biomolecules in the body and health-related clinical information over time together with the environment and lifestyle. The uniqueness of this human biology study is the multidisciplinary research infrastructure incorporating information science, mathematics, and social sciences. Cutting-edge technology in genomic medicine such as next-generation sequencing and multi-omics measurements is combined with an objective evaluation of environmental factors, records on sleep and other body activities, and the comprehensive social capital survey. Various research programmes have been launched on this information infrastructure, such as a skin aging study with industry and an association study between genetic factors and social and economic behaviour in collaboration with a governmental research institute. From 2020, a new socio-life science study for the COVID-19 pandemic consisting of SARS-CoV-2 antibody measurement and social capital surveys was initiated as a joint research effort of academia, government and industry.

Keywords Human biology · Pre-primary prevention · Genomic cohort · Multi-omics analysis · Socio-life science

1 Human Biology with Integrated Human Life Information

Epidemiological approaches using large-scale cohorts conducted in Japan and overseas have contributed significantly to elucidating risk factors and proposing preventive methods for diseases that are difficult to accomplish only by fundamental

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researches using cells and model animals or clinical investigations based on patient morbidity information. These studies often use macroscopic biomarkers such as physique and blood pressure with a limited number of typical biochemical measurements. However, the risk of developing the disease has not been fully explained only with these classical risk factors because of human genetic diversity.

On the other hand, genomic analysis technology, which has grown rapidly since the beginning of this century, has successfully applied to human disease genomics and enabled identifying susceptibility genes for a number of multifactorial disorders in a cross-sectional manner. Nonetheless, few cases directly contributed to disease mechanism elucidation, development of new treatments and drugs, and the prevention and therapy of such diseases. These facts strongly show the limitation of epidemiological approaches focusing only on classical risk factors and cross-sectional disease studies using genomic analysis.

Recent studies of human disease and aging focus more on intermediate phenotypes such as transcripts, proteins/peptides, and metabolites in addition to genomic information. Such biomolecule information is crucial to trace as biomarkers because these phenotypes directly reflect physiological conditions, including aging, and are associated with the onset and progression of various diseases. On the other hand, unlike genomic information, they change over time. Thus, to discover novel risk factors and disease-related biomarkers using intermediate phenotypes, it is crucial to comprehensively measure time-series biological samples obtained from a large number of healthy subjects using cutting-edge analytical technology and conduct an integrative analysis with health-related information such as environment and lifestyle, and disease morbidity.

The Nagahama Prospective Cohort for Comprehensive Human Bioscience (the *Nagahama Study*) is the first large-scale multipurpose genome cohort in Japan, recruiting 10,000 healthy individuals in Nagahama City of Shiga Prefecture. In this project, we have conducted an extensive health check once every five years, including physiological measurements, laboratory tests using blood and urine, and collected lifestyle, clinical, and environmental information. We also accumulated data on the onset, pathophysiology, and prognosis of diseases through periodical follow-up surveys of disease morbidity and death. In addition, time-series blood and urine samples have been collected and stored for analysis and measurement. A large-scale, high quality, and advanced research design enabling the discovery of novel biomolecules involved in diseases and aging considering human diversity has been highly evaluated worldwide. It plays an essential role as a research infrastructure for human biology and contributes to various genomic epidemiological studies.

2 The Nagahama Study and Its Background

The *Nagahama Study* has been jointly implemented by Kyoto University Graduate School of Medicine and Nagahama City in Shiga Prefecture since 2007. This project aims to improve health awareness of oneself and the community and introduce new

Fig. 1 Location of Nagahama city

health promotion passed on to the next generation. It consists of more than 10,000 healthy residents of Nagahama and is considered the largest cohort recruiting inhabitants of a single city (Fig. 1). Nagahama is a medium-sized local city with approximately 120,000 people and is located in the northeastern part of Lake Biwa, the largest lake in Japan. The proportion of the elderly aged 65 and over was around 20% at the beginning of the project in 2007. It has increased to approximately 28% in recent years, showing the same transition as the national level in Japan. Therefore, it is suitable for epidemiological studies that reflect the aging society in Japan. Nagahama City has a small population inflow and outflow. In addition, three core hospitals in the city form a medical service area of more than 200,000 people centered on Nagahama City. Therefore, it is possible to track the disease onset status of cohort study participants over a long period. This project contributes to the health promotion of Nagahama citizens through genomic epidemiology research and dissemination and enlightenment activities related to health. Nagahama citizens established the NPO "Health Promotion Zeroji Club". It supports this study from various aspects, such as recruiting participants for the project, managing medical checks, and organizing multiple health promotion activities.

3 The Concept of "pre-Primary Prevention"

In preventive medicine, which aims to prevent diseases that threaten health, the prevention stage is divided into three phases, namely, primary prevention (health promotion), secondary prevention (early detection and treatment), and tertiary prevention (rehabilitation). However, each individual is unique, and uniform prevention based on population averages may not be optimal for that individual. Therefore, we proposed the concept of "pre-primary prevention" ("Zero-Ji Yobou" in Japanese), which refers to a new concept of prevention that precedes primary prevention. It aims to realize optimal and early disease prevention for each individual based on their genetic background and detailed measurement of biomolecules in the body such as proteins, lipids, and metabolites. The importance of prevention prior to primary prevention has been advocated for a long time, and one example is the concept of primordial prevention proposed by Strasser (1978). Its idea was to prevent cardiovascular disorders by changing the sense of values in the population and the structure of the socio-economic environment to prevent the penetration of risk factors into the population. For example, activities to prevent the spread of undesirable eating habits in the population that increase disease risk by distributing reasonably-priced healthy foods and encouraging children to acquire desirable eating habits from school age were assumed. Primordial prevention precedes primary prevention but differs from pre-primary prevention in that it attempts to reduce risk through uniform guidance. Pre-primary prevention is a concept that leads to preemptive medicine, which aims to realize the lifelong increase of the quality of life by preventing or delaying the onset of disease through highly accurate pre-onset diagnosis and early intervention that is optimal for the individual.

4 The Nagahama Rules

At the start of this project, the national ethical guidelines did not cover the various issues to be addressed in this project, such as acquiring global consent including the whole-genome analysis of apparently healthy individuals. Hence it was necessary to create our own rules on research ethics. Based on the current guidelines and local regulations, we conducted a pilot survey of a small number of people in 2007. Considering the issues that materialized through the survey, the "Nagahama Rules" were formulated after a lengthy discussion among medical biologists, experts in ethics and law, the Nagahama local government, and residents' representatives. In June 2008, these rules were made legally binding by being enacted as an ordinance of Nagahama City. Although it was a groundbreaking rule at the time of its enactment, social conditions and guidelines related to research ethics have changed. Therefore, careful discussions are ongoing among researchers, government officials, and experts to update it flexibly adapted to such changes and continue to be a fundamental principle of the project.

5 Survey Summary

5.1 *Baseline Survey (FY 2007~2010)*

The baseline survey recruited Nagahama citizens based on the following conditions: (1) between the ages of 30 and 74, (2) able to participate on their own, (3) no significant communication difficulties, (4) no severe diseases, symptoms, or health problems, and (5) autonomous decision to cooperate and participate in the project. The project started with a small number of participants (273) in 2007, and a total of 10,082 people have enrolled by November 2010. A written global informed consent was obtained from each participant, allowing researchers to use biological materials and information for future analysis and research in line with technological development.

5.2 *First Follow-Up Survey (FY 2012–FY 2016)*

Between the baseline and the first follow-up surveys, 370 individuals died or moved out of the city, and 16 withdrew the consent. As a result, 9698 were targets of the follow-up health check. Out of the 9698 individuals, 8559 returned to the follow-up, and the return rate was as high as 88.3% (8559/9698). In 2016, we conducted additional recruitment and obtained 1561 new participants, bringing the total number of participants at the end of the first follow-up to 10,120. In addition, we initiated an investigation of disease incidence during this period, which allowed the analysis of cerebrovascular and ischemic heart disease incidence using the medical record information of the three major hospitals in Nagahama City, namely, Nagahama Municipal Hospital, Kohoku Hospital, and Nagahama Red Cross Hospital.

5.3 *Second Follow-Up Survey (FY 2017–)*

In the second follow-up survey, 4754 people underwent medical check-ups in the three years up to FY2019. However, we needed to postpone health check-ups for FY 2020 due to the outbreak of COVID-19, expecting it takes place in FY 2021.

6 Survey Items

6.1 Questionnaire Survey

This survey aims to screen the participants' environment, lifestyle, and past and potential illnesses. To increase the accuracy of the dataset and avoid missing values, we asked participants to submit their answers before the health check-up and filled the unanswered parts with them at the venue. The main questions are shown in Table 1.

There are reports on the identification of factors related to poor sleep (Matsumoto et al. 2017a) and the risk for long-lasting cough (Matsumoto et al. 2017b), and the evaluation of diabetes risk based on the number of chewing (Yamazaki et al. 2013) using the questionnaire.

6.2 Biochemical Tests

A variety of measurements, including those not measured in the routine health check-up, were performed using blood and urine samples (Table 2). We returned measurement results with established clinical significance to the participants and contributed to the participants' health promotion plans. The specimens (plasma, serum, and urine) are collected and stored at the biorepository of the Center for Genomic Medicine, Kyoto University Graduate School of Medicine, and are used for research-based measurements.

6.3 Physiological Examination

We conducted measurements and examinations related to respiratory function, cardiovascular function, dentistry, and ophthalmology to evaluate physical functions (Table 3). Research results using the data include reports which revealed tooth loss in males and thinner retinal blood vessels measured by fundus photographs were associated with arteriosclerosis development (Asai et al. 2015; Kawashima-Kumagai et al. 2018). Furthermore, in 2007, the Japan Orthopedic Association proposed "locomotive syndrome" as a condition in which mobility function declines due to musculoskeletal disorders. Therefore, we conducted examinations to evaluate the locomotive syndrome in the first follow-up, including muscle strength and sense-of-balance measurements for 2127 participants aged 60 years or older (Table 4). These examinations revealed that hip muscle strength affects walking speed and stability only in women and that there are gender differences in the causes of walking difficulties (Inoue et al. 2017). We also discovered that a smaller lumbar kyphosis increases

Table 1 Measurements by questionnaire in the *Nagahama Study*

1. Questions for lifestyle and environmental factor related with health risk	
Basic information	Demographic/social information, weight change, occupation, educational background, cohabitation status, marital status
Life style information	Sleeping status, physical activity and fitness habits, undefined compliant
Alcohol intake	Drinking habits (kinds of alcohol, frequency, amount), age at abstinence
Cigarette smoking	Number of smoking year, number of smoking cigarettes, willingness to quit smoking, passive smoking history
Mental health	Partial SF36 (mental health: 5-item, social role: 7-item), depressive symptom
Anamnestic history	Disease history of participants and their family, mediation
Female health	Pregnant status, delivery history, menstrual status, female specific anamnestic history
Dietary lifestyle	Food habits (frequency, amount, time spent in a meal), dietary supplement, health food, food intake (kinds of food, frequency)
2. Questions for potential disease screening	
Gastroenterology	History of gastroenterological diseases (hepatitis, reflux esophagitis), interferon therapy
Respiratory medicine	Status of cough and wheeze, respiratory symptoms, history of respiratory disease (cold, hay fever, asthma, pulmonary diseases), pet breeding, activity in at-risk area for a respiratory diseases
Orthopedic surgery	Symptoms in knee and back, activity restriction because of back pain, complaint because of back pain
Urology	Complaints of urinary problems, frequency of urination, degree and frequency of urinal leakage, causal situation of urinal leakage
Rheumatology and immunology	Typical symptoms for collagen diseases and rheumatoid arthritis
Ophthalmology	History of eye diseases (myopia, hyperopia, astigma, glaucoma, cataract, age-related macular degeneration), history of operation for eye diseases
Oral and maxillofacial surgery	Dental treatment, complaint about oral state, history off oral diseases, masticatory ability (chewable food), tooth brushing habits (time spent in brushing, frequency, tools for brushing)

blood pressure during standing and a stooped posture is a determinant of orthostatic hypertension, which has been overlooked so far (Tabara et al. 2019).

In addition, we introduced cognitive function tests (Hasegawa scale and mild cognitive impairment (MCI) screening), head and neck MRI/MRA, and knee radiographs for participants aged 60 and over. 4923 people underwent cognitive function tests, of which 3191 took MRI/MRA tests. In 2013, we initiated a programme to monitor sleep and nocturnal blood pressure. This programme objectively assessed

Table 2 Measured biomarkers in the *Nagahama Study*

Sample	Measurements	Study		
		baseline (2007–2010)	1st follow-up (2012–2016)	2nd follow-up (2017–)
Blood	Complete blood count (13-item)	○	○	○
	Hemoglobin	○	○	○
	Hematocrit	○	○	○
	Glucose	○	○	○
	Hemoglobin A1c	○	○	○
	Insulin	○	○	○
	Total protein	○	○	○
	Albumin	○	○	○
	Globulin		○	○
	Total bilirubin	○	○	○
	Direct bilirubin		○	○
	Indirect bilirubin		○	○
	Alkali phosphatase (ALP)	○	○	○
	Aspartate aminotransferase (AST)	○	○	○
	Alanine aminotransferase (ALT)	○	○	○
	Gamma-glutamyl transferase (GGT)	○	○	○
	Choline esterase	○	○	○
	Total cholesterol (T-Ch)	○	○	○
	Low-density lipoprotein cholesterol (LDL-C)	○	○	○
	High-density lipoprotein cholesterol (HDL-C)	○	○	○
	Cholesterol subclass (5-item)	○		
	Rheumatoid factor (RF)	○		
	Anti-cyclic citrullinated peptide antibody	○		
	Antinuclear antibody (ANA) (8-item)	○		
	Nonspecific immunoglobulin E	○		
	Specific immunoglobulin E (8-item)	○		

(continued)

Table 2 (continued)

Sample	Measurements	Study		
		baseline (2007–2010)	1st follow-up (2012–2016)	2nd follow-up (2017–)
	Anti-chlamydia pneumonia antibody (IgG, IgA)	○		
	Anti-mycoplasma pneumonia IgA	○		
	Triglyceride	○	○	○
	Free fatty acid	○	○	
	Creatinine	○	○	○
	Uric acid	○	○	○
	Sodium		○	○
	Potassium		○	○
	Calcium	○	○	○
	Inorganic phosphate	○	○	○
	Chloride		○	○
	B-type natriuretic peptide (BNP)	○	○	○
	N-terminal pro-BNP (NT-pro BNP)		○	△
	Alpha-1 antitrypsin (AAT)	○		
	Angiotensin-converting enzyme (ACE)	○		
	High-sensitivity C reactive protein (hs-CRP)	○	○	○
	High-sensitivity prostate specific antigen (hs-PSA)	○	○	
Urine	Glucose	○	○	○
	Protein	○	○	○
	Blood	○	○	○
	Urobilinogen	○	○	○
	Bilirubin	○	○	○
	Sodium	○	○	○
	Potassium	○	○	○
	Ketone	○	○	○
	Microalbumin	○	○	○
	Creatinine	○	○	○

(continued)

Table 2 (continued)

Sample	Measurements	Study		
		baseline (2007–2010)	1st follow-up (2012–2016)	2nd follow-up (2017–)
	Cotinine	○		
	Beta C-terminal telopeptide	○		
	Type 1 collagen cross-linked N-terminal telopeptide	○		
	Power of hydrogen (pH)	○	○	○
	Specific gravity	○	○	○
	Urinary sediment (10-item)	○	○	○
	24 h urine collection(12-item)			○

○: Measured, △: Partially measured (limited period or limited subject)

the sleep length and cycle, and frequency of mid-wake, which subjective and low-quality questionnaires had been used for evaluation. We also investigated the presence of sleep apnea syndrome (SAS). Home blood pressure is considered more accurate than clinic blood pressure, and sleep blood pressure is a risk indicator for cardiovascular disease independent of daytime blood pressure. For this purpose, an oxygen saturation monitor, a wristwatch-type activity monitor, and a blood pressure monitor were loaned to the participants for approximately one week. The tests were conducted at home. 7647 participants joined the sleep test, which resulted in the accumulation of sleep data at the world's largest scale. We showed that SAS and hypertension/diabetes interact with each other and that their relationship is clinically noteworthy (Matsumoto et al. 2018a). We also revealed that blood pressure variability during sleep is not only diurnal but also seasonal (Tabara et al. 2018). Furthermore, poor quality sleep, especially nocturia, was shown to interfere with blood pressure reduction during sleep (Matsumoto et al. 2018b).

6.4 Genomic and Omics Analysis

We conducted a whole-genome SNP typing analysis using 9020 DNA samples obtained in the study. Out of these samples, 1695 were subjected to whole-genome sequencing using Next Generation Sequencing (NGS) technology. In addition to genomic analysis, we conduct intermediate trait analysis focusing on biomolecules in plasma such as metabolites, lipids, and proteins/peptides using mass-spectrometry and other technologies (Table 5). We finished the measurement of the metabolome

Table 3 Physiological measurements in the *Nagahama Study*

Category	Measurements	Study		
		baseline	1st follow-up	2nd follow-up
Anthropometric index	*Haight, weight, abdominal circumstance, body composition (fat, muscle, water)*	○	○	○
			○	○
Respiratory index	Spirometry	○	○	○
	Chest X-ray	○		
	Sleep apnea syndrome (SpO_2)		○	○
	Diaphragm echo			△
	Arteriosclerosis (CAVI, ABI, PWV)	○	○	○
Cardiovascular index	Blood pressure (SBP, DBP, cSBP)	○	○	○
	Orthostatic blood pressure		○	○
	Domestic and nocturnal blood pressure		○	○
	Echocardiography			△
	Carotid ultrasonography		○	○
	Advanced glycation end products		○	△
	Ear robe photograph		○	
Sensory system	Tactile recognition			○
	Double flash illusion test			○
Ophthalmic test	Fundus photograph	○	○	○
	Axial length	○	○	○
	Refractive index	○	○	○
	Intraocular pressure	○	○	○
	Optical coherence tomography		○	○
	Eye sight			△
	Visual field test			○
	Accommodation ability			○
	Ocular position			○
Dental check	Oral status (caries, periodontitis)	○	○	○
	Mastication ability	○	△	
Brain function	Cognitive function (dementia, MCI)		○	○
	Head/neck MRI, MRA		○	○

(continued)

Table 3 (continued)

Category	Measurements	Study		
		baseline	1st follow-up	2nd follow-up
Physical function	Measurements for locomotive syndrome		○	△
	Knee X-ray/MRI		○	○
	Bone density		○	

○: Measured, △: Partially measured (limited period)

Table 4 Measurements for locomotive syndrome in the *Nagahama Study*

Category	Measurement
Balance	Stabilometry, one-leg standing duration, stepping test
Muscular strength	Grip strength, knee extension force, toe grip strength, hip extensor force, hip abductor force, hip flexor fore, ankle plantar flexor force
Walking ability	10 m normal walk test, 10 m maximum walk test
Physical ability	Knee range of motion
Image inspection	Flat foot (echo imaging), pes valgus, (photograph), hallux valgus, (photograph)
Total motor function	Short physical performance battery (SPPB), Timed up and go test (TUGT), Locomo test
Questionnaire	The knee society score (Japanese)

Table 5 Omics analyses in the *Nagahama Study* (as of March 1, 2021)

Measurement	Method	Number of subjects
Genome analysis		
Exhaustive SNP typing	Genome scan (Illumina)	9020
Whole genome sequence	Next generation sequence (Illumina)	1695
Metabolome/lipidome analyses		
Hydrophilic metabolite (136-item)	Gas chromatography—mass spectrometry (GC–MS) (Shimadzu)	Baseline: 9775 1st follow-up: 9871 2nd follow-up: 3441
Hydrophilic metabolite (220-item)	Liquid chromatography mass spectrometry (LC–MS) (Shimadzu)	1st follow-up: 3648 2nd Follow-up: 358
Lipid metabolite (268-item)	Liquid chromatography mass spectrometry (LC–MS) (Shimadzu)	Baseline: 5707 1st follow-up: 8314 2nd follow-up: 358
Cell subsets analysis		
Markers for immune cell subsets (23-item)	Flow cytometry (SONY)	1st follow-up (October, 2014): 226
Proteome analysis		
Exhaustive protein assay (4808-item)	Aptamer assay (Soma Logic)	1st follow-up: 2000

in 9775 and 8316 plasma samples obtained at the baseline and the first follow-up surveys, respectively.

Many genome-wide association analyses have been conducted in this project to search for genetic determinants associated with traits and disease susceptibility. For example, reports have been made on the identification of biochemical markers (Setoh et al. 2015; Terao et al. 2014), amino acid profiles (Imaizumi et al. 2019), and novel gene regions associated with myopic maculopathy (Hosoda et al. 2018), a cause of blindness. Whole-genome SNP genotyping information is available to researchers through the National Bioscience Database Center (NBDC).

7 Related Research

7.1 Integrated Omics Research Aimed at Elucidating the Mechanism of Skin Aging

The skin is a vital tissue that serves as a barrier to protect the entire body from the surrounding environment. Skin-aging progresses due to ultraviolet light stimulation and aging, resulting in appearance changes with wrinkles and decreased water content in the skin. Visual skin aging affects communication in social life. In addition, it has been reported to be associated with systemic age-related diseases such as cardiovascular diseases and cognitive impairment (Christensen et al. 2009; Gunn et al. 2013). The study aiming to elucidate skin-aging mechanisms and identify associated factors was jointly conducted with CHANEL Research and Technology, Inc. 1252 participants joined the study in 2014. Skin elasticity and reflectance were measured, and high-resolution facial photo images were collected. We performed an integrated omics analysis of such skin condition-related markers with health-related questionnaires and genome/omics measurements. Analysis results successfully lead to the development of a new skin-care product. The first follow-up survey is scheduled for winter 2021.

7.2 Survey on Social and Economic Behaviour

It is known that social science factors such as social environment, economy, politics, and medical and biological factors affect people's health and diseases (Braveman and Gottlieb 2014). For example, preventive awareness of illnesses is related to risk judgment and decision-making (Tsutsui et al. 2010) and social relationships affect health and mortality (Holt-Lunstad et al. 2010; Kagamimori et al. 2009). In this project, the Institute of Economic Research of Kyoto University is taking the lead in conducting a questionnaire-based survey on social and economic behaviour. The survey has been conducted three times, in 2016, 2018, and 2020, with a response rate of approximately 70% in each survey. The survey items include a wide range of socio-economic factors such as education and income, risk aversion, time discount rate, sense of fairness, sense of trust, attitude toward uncertainty, and items related to local networks. As an example of the results of this study, an analysis of social capital indexed in (1) social networks and support, (2) participation in social activities, and (3) trust in people, revealed that social capital has an impact on having "motivation for health" (improving lifestyle and receiving health guidance) (Sekine et al. 2020).

7.3 Socio-Life Science Study for COVID-19 Pandemic

The COVID-19 pandemic showed a nationwide spread of infection in Japan and significantly impacted ordinary lifestyles and the economy. Therefore, we are conducting a study by combining antibody tests and questionnaire surveys on 3000 residents participating in the *Nagahama Study*. This study aims to (1) accurately identify the actual status of SARS-CoV-2 infection, including subclinical infections, (2) identify populations at high risk of the infection, and (3) understand people's behavioural changes under the pandemic and started the survey in March 2021.

The statistics for COVID-19 in Japan are based on examining only those who have symptoms or have had contact with infected people. Therefore, subclinical populations (Liang et al. 2020) with no noticeable symptoms after infection are overlooked. In this study, we perform antibody tests to capture infection history, including subclinical cases accurately. We will use a highly accurate COVID-19 antibody test developed by the Pasteur Institute in France, which measures antibody titers against multiple epitopes of SARS-CoV-2. Therefore, it is a method with significantly improved sensitivity and specificity than conventional antibody tests that only detect antibodies to a limited number of epitopes (Rosado et al. 2021).

To assess factors that increase the risk of the spread of infection, it is essential to evaluate the correct knowledge and behaviour toward SARS-CoV-2 infection. In addition to medical and epidemiological factors such as age, presence of underlying diseases (Huang et al. 2020), awareness of prevention (for example, wearing masks, etc.) (Zhang et al. 2020), visiting epidemic areas and contact with infected people (Cohen et al. 2020), social scientific factors such as people's judgment of risk, mode of thinking and behaviour, and social status also affect the spread of infection. For example, the words and actions of the political party or politician one supports are said to influence individual risk management and are related to SARS-CoV-2 infection and COVID-19 incidence (Allcott et al. 2020). Therefore, the survey uses a questionnaire consisting of approximately 100 interactive questions from medicine and social science, which was developed in cooperation with the Research Institute of Economy, Trade and Industry (RIETI). For example, the questionnaire traces medical aspects such as underlying disease and observed symptoms, socio-economic factors such as risk preference, trust in the country or region, social ties, and economic status. Also, it contains changes in daily behaviour and preventive awareness that have occurred every three months since the emergence of COVID-19.

We expect that the findings obtained from this study give essential hints on dealing with COVID-19 in the future and as a basis for reasonable quarantine measures required in the event of a possible epidemic of emerging or reemerging infectious diseases in the future.

References

Allcott H, Boxell L, Conway J, Gentzkow M, Thaler M, Yang D (2020) Polarization and public health: partisan differences in social distancing during the coronavirus pandemic. J Public Econ 191:104254

Asai K, Yamori M, Yamazaki T, Yamaguchi A, Takahashi K, Sekine A, Kosugi S, Matsuda F, Nakayama T, Bessho K, Nagahama Study Group (2015) Tooth loss and atherosclerosis: the Nagahama study. J Dent Res 94:52S–58S

Braveman P, Gottlieb L (2014) The social determinants of health: it's time to consider the causes of the causes. Public Health Rep 129:19–31

Christensen K, Doblhammer G, Rau R, Vaupel JW (2009) Ageing populations: the challenges ahead. Lancet 374:1196–1208

Cohen IG, Gostin LO, Weitzner DJ (2020) Digital smartphone tracking for COVID-19: public health and civil liberties in tension. JAMA 323:2371–2372

Gunn DA, de Craen AJ, Dick JL, Tomlin CC, van Heemst D, Catt SD, Griffiths T, Ogden S, Maier AB, Murray PG, Griffiths CE, Slagboom PE, Westendorp RG (2013) Facial appearance reflects human familial longevity and cardiovascular disease risk in healthy individuals. J Gerontol Ser A Biol Sci Med Sci 68:145–152

Holt-Lunstad J, Smith TB, Layton JB (2010) Social relationships and mortality risk: a meta-analytic review. PLoS Med 7:e1000316

Hosoda Y, Yoshikawa M, Miyake M, Tabara Y, Shimada N, Zhao W, Oishi A, Nakanishi H, Hata M, Akagi T, Ooto S, Nagaoka N, Fang Y, Nagahama Study group, Ohno-Matsui K, Cheng CY, Saw SM, Yamada R, Matsuda F, Tsujikawa A, Yamashiro K (2018) CCDC102B confers risk of low vision and blindness in high myopia. Nat Commun 9:1782

Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, Zhang L, Fan G, Xu J, Gu X, Cheng Z, Yu T, Xia J, Wei Y, Wu W, Xie X, Yin W, Li H, Liu M, Xiao Y, Cao B (2020) Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 395:497–506

Imaizumi A, Adachi Y, Kawaguchi T, Higasa K, Tabara Y, Sonomura K, Sato TA, Takahashi M, Mizukoshi T, Yoshida HO, Kageyama N, Okamoto C, Takasu M, Mori M, Noguchi Y, Shimba N, Miyano H, Yamada R, Matsuda F (2019) Genetic basis for plasma amino acid concentrations based on absolute quantification: a genome-wide association study in the Japanese population. Eur J Hum Genet 27:621–630

Inoue W, Ikezoe T, Tsuboyama T, Sato I, Malinowska KB, Kawaguchi T, Tabara Y, Nakayama T, Matsuda F, Ichihashi N (2017) Are there different factors affecting walking speed and gait cycle variability between men and women in community-dwelling older adults? Aging Clin Exp Res 29:215–221

Kagamimori S, Gaina A, Nasermoaddeli A (2009) Socioeconomic status and health in the Japanese population. Soc Sci Med 68:2152–2160

Kawashima-Kumagai K, Tabara Y, Yamashiro K, Setoh K, Yoshikawa M, Kawaguchi T, Miyake M, Nakanishi H, Muraoka Y, Takahashi Y, Kosugi S, Nakayama T, Yoshimura N, Matsuda F, Tsujikawa A, Nagahama Study group (2018) Association of retinal vessel calibers and longitudinal changes in arterial stiffness: the Nagahama study. J Hypertens 36:587–593

Liang WH, Guan WJ, Li CC, Li YM, Liang HR, Zhao Y, Liu XQ, Sang L, Chen RC, Tang CL, Wang T, Wang W, He QH, Chen ZS, Wong SS, Zanin M, Liu J, Xu X, Huang J, Li JF, He JX (2020) Clinical characteristics and outcomes of hospitalised patients with COVID-19 treated in

Hubei (epicentre) and outside Hubei (non-epicentre): a nationwide analysis of China. Eur Respir J 55:2000562

Matsumoto T, Tabara Y, Murase K, Takahashi Y, Setoh K, Kawaguchi T, Muro S, Kadotani H, Kosugi S, Sekine A, Yamada R, Nakayama T, Mishima M, Matsuda F, Chin K (2017a) Combined association of clinical and lifestyle factors with non-restorative sleep: the Nagahama Study. PloS ONE 12:e0171849

Matsumoto H, Izuhara Y, Niimi A, Tabara Y, Nagasaki T, Kanemitsu Y, Murase K, Oguma T, Ito I, Muro S, Sekine A, Matsuda F, Kosugi S, Nakayama T, Chin K, Mishima M, Nagahama Study Collaboration Group (2017b) Risks and cough-aggravating factors in prolonged cough. epidemiological observations from the Nagahama cohort study. Ann Am Thorac Soc 14:698–705

Matsumoto T, Murase K, Tabara Y, Gozal D, Smith D, Minami T, Tachikawa R, Tanizawa K, Oga T, Nagashima S, Wakamura T, Komenami N, Setoh K, Kawaguchi T, Tsutsumi T, Takahashi Y, Nakayama T, Hirai T, Matsuda F, Chin K (2018a) Impact of sleep characteristics and obesity on diabetes and hypertension across genders and menopausal status: the Nagahama study. Sleep 41. https://doi.org/10.1093/sleep/zsy071

Matsumoto T, Tabara Y, Murase K, Setoh K, Kawaguchi T, Nagashima S, Kosugi S, Nakayama T, Wakamura T, Hirai T, Matsuda F, Chin K, Nagahama study group (2018b) Nocturia and increase in nocturnal blood pressure: the Nagahama study. J Hypertens 36:2185–2192

Rosado J, Pelleau S, Cockram C, Merkling SH, Nekkab N, Demeret C, Meola A, Kerneis S, Terrier B, Fafi-Kremer S, de Seze J, Bruel T, Dejardin F, Petres S, Longley R, Fontanet A, Backovic M, Mueller I, White MT (2021) Multiplex assays for the identification of serological signatures of SARS-CoV-2 infection: an antibody-based diagnostic and machine learning study. The Lancet. Microbe 2:e60–e69

Sekine Y, Li H, Inoue H, Hirota S, Yodo M, Setoh K, Tabara Y, Matsuda F, Yano M (2020) Motivation and social capital for health behaviors related to lifestyle improvement. Kyoto Institute of Economic Research Discussion Paper. No. 2001

Setoh K, Terao C, Muro S, Kawaguchi T, Tabara Y, Takahashi M, Nakayama T, Kosugi S, Sekine A, Yamada R, Mishima M, Matsuda F (2015) Three missense variants of metabolic syndrome-related genes are associated with alpha-1 antitrypsin levels. Nat Commun 6:7754

Strasser T (1978) Reflections on cardiovascular diseases. Interdisc Sci Rev 3:225–230

Tabara Y, Matsumoto T, Murase K, Nagashima S, Hirai T, Kosugi S, Nakayama T, Wakamura T, Chin K, Matsuda F, Nagahama study group (2018) Seasonal variation in nocturnal home blood pressure fall: the Nagahama study. Hypertens Res 41:198–208

Tabara Y, Masaki M, Ikezoe T, Setoh K, Kato T, Kawaguchi T, Kosugi S, Nakayama T, Ichihashi N, Tsuboyama T, Matsuda F, Nagahama Study Group (2019) Small degree of lumbar lordosis as an overlooked determinant for orthostatic increases in blood pressure in the elderly: the Nagahama Study. Am J Hypertens 32:61–69

Terao C, Terada N, Matsuo K, Kawaguchi T, Yoshimura K, Hayashi N, Shimizu M, Soga N, Takahashi M, Nagahama Cohort Study Group, Kotoura Y, Yamada R, Ogawa O, Matsuda F (2014) A genome-wide association study of serum levels of prostate-specific antigen in the Japanese population. J Med Genet 51:530–536

Tsutsui Y, Benzion U, Shahrabani S, Din GY (2010) A policy to promote influenza vaccination: a behavioral economic approach. Health Policy 97:238–249

Yamazaki T, Yamori M, Asai K, Nakano-Araki I, Yamaguchi A, Takahashi K, Sekine A, Matsuda F, Kosugi S, Nakayama T, Inagaki N, Bessho K, Nagahama Study Collaboration Group (2013) Mastication and risk for diabetes in a Japanese population: a cross-sectional study. PloS ONE 8:e64113

Zhang R, Li Y, Zhang AL, Wang Y, Molina MJ (2020) Identifying airborne transmission as the dominant route for the spread of COVID-19. Proc Natl Acad Sci USA 117:14857–14863

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Fumihiko Matsuda obtained his Ph.D. from Kyoto University Graduate School of Medicine in 1990 under Professor Tasuku Honjo and continued his research with him until 1998. Throughout this period, his work is the organization of the human immunoglobulin heavy-chain variable-region (VH) gene locus. In 1998, he joined Centre National de Genotypage (CNG) in Evry, France, as the head of gene identification. During his stay at CNG for ten years, he played a significant role in numerous comprehensive genetic analyses of multigenetic disorders. Since holding a joint appointment as a Professor of the Center for Genomic Medicine at Kyoto University in 2003, he focused on the trans-ethnic genetic studies of human diseases. Since 2012, he has led an international collaboration with McGill University in genomics and contributed to establishing an International Joint Degree Programme in Genomic Medicine between Kyoto and McGill. The programme was initiated in April 2018. Since 2016, he is currently the scientific coordinator of Pasteur-Kyoto International Research Unit for Vaccinomics. Also, he has served as the research director of RADDAR-J, a nationwide rare disease platform programme in Japan supported by AMED since 2017.

Professor Matsuda has consistently devoted himself to researching human genetics and genomics by integrated omics analysis of human disorders through various positions he has engaged. He has experience working in France for ten years with international collaborators. He is also promoting international collaborations with Asian countries, including China, Korea, and Thailand, as well as with France, Canada, and the UK.

Professor Matsuda is Chevalier de l'Ordre National du Mérite.

Chapter 8
Nagahama Survey on Social Science

Makoto Yano, Shigeru Hirota, Masato Yodo, and Fumihiko Matsuda

Abstract The *Nagahama Social Science Survey* is designed to add a social scientific scope to the *Nagahama Prospective Genome Cohort for Comprehensive Human Bioscience* conducted by the Center for Genomic Medicine at Kyoto University. Since 2016, it has been conducted three times; all the surveys share the same questionnaire to build a panel (cohort) data. Each survey also collected data based on its own theme as well. In this chapter, we explain the theme and questionnaire for the first survey and discuss basic summary statistics.

Keywords Health · Happiness · Social capital · Cohort · Questionnaire · Nagahama

1 Introduction

Human behaviour depends on various social scientific factors, including income and wealth, risk attitudes, family, and views on various social and political issues. At the

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This study is conducted as a part of the Project "Toward Building Socio-Life Science" undertaken at the Research Institute of Economy, Trade and Industry (RIETI).

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same time, it is heavily influenced by life scientific factors, including biological treats, mental state, and medical histories. As the recent outbreak of COVID-19 evidences, therefore, epidemiological issues cannot be fully understood without taking the interaction of all those social and life scientific factors into account. Similarly, social scientific studies on human behaviour must take into account both social and life scientific factors. Despite this, however, social scientific research and life scientific research have traditionally been conducted in a separate manner. In particular, basic research data concerning human behaviour has been compiled independently in those two fields. It is our view that this has badly hampered a healthy development of a scientific field encompassing social and life science, which we call socio-life science.

With these considerations, we initiated to build socio-life science panel (cohort) data at Kyoto University in 2016, which is made possible by a collaboration between the Graduate School of Medicine and the Institute of Economic Research at the university. Building this panel data, we have conducted social scientific surveys (*Nagahama Social Science Survey* or, simply, *Nagahama Survey*) so as to add a social scientific scope to the existing genome cohort data compiled at the Center for Genomic Medicine, the *Nagahama Prospective Genome Cohort for Comprehensive Human Bioscience* (the *Nagahama Study*), focusing on bioscientific aspects of humans; for details of this genome cohort data, see Setoh and Matsuda (2021). The *Nagahama Survey*, which targets participants of the *Nagahama Study*, has been conducted three times so far (fiscal years 2016, 2018, and 2020). The data altogether provide information not only social scientific aspects of life but also bioscientific features, including genomic information.

Recently, a number of social scientific panel data projects have started to add genomic information. Our survey is unique in that survey questions are designed in such a way to make full use of genomic information in social scientific approach, which is collected in the *Nagahama Study*, at the same time that social scientific factors can be incorporated into bioscientific research.

The three social science surveys constitute panel data. They seek the same basic information from participants. At the same time, they have different emphases. In this chapter, we explain the purpose of our first social scientific survey in 2016 in relation to our survey questions; the first survey's emphasis is on the factors that might put a society together or, in other words, serve as a social bond. As a part of this panel data, we have conducted an additional survey on the formation of COVID-19 antibody and behaviour change in 2021. On this survey, see Hirota et al. (2021).

In Sect. 2, we explain the basic way in which data is compiled. In Sect. 3, we explain the survey questions and descriptive statistics. The actual questions (originally in Japanese) are presented in the appendix.

2 Outline of the Nagahama Social Science Survey

This survey is to add a social scientific scope to the *Nagahama Prospective Genome Cohort for Comprehensive Human Bioscience* (the *Nagahama Study*), which is a genome cohort survey focusing on bioscientific aspects of humans (for details on the *Nagahama Study*, see Setoh and Matsuda 2021). Our survey, which targets participants of the *Nagahama Study*, has been conducted three times (fiscal years 2016, 2018, and 2020). Each time, survey questionnaires were sent by mail to all survey participants, namely, 8482 participants for the first survey, 9813 participants for the second, and 9737 for the third. The number of valid answers was 5954 (70.2%) in the first, 6988 (71.2%) in the second, and 6776 (69.6%) in the third.

A non-profit organization, the Zero-Ji Health Promotion Club, sent out and collected questionnaires, and cleaned up data so that, by the time we received, it was made completely anonymous. Each question, and its use of answers in association with life-scientific data, has been approved by the independent ethics committee organized by the city of Nagahama, which authorizes the *Nagahama Study* by its city ordinance. See Setoh and Matsuda (2021) for details on the approval process of the surveys conducted under the *Nagahama Study*.

The *Nagahama Study* accepts multiple members of a single family as respondents. As a result, all the survey results represent a respondent personal views and states, but not that of the household to which a respondent belong. We cannot identify individuals who have their family member(s) participating in the survey.

3 First Nagahama Survey (2016 Survey)

The 2016 *Nagahama Survey*, which is the first of the three surveys conducted so far, has two major purposes. The first is to investigate what holds a society together in relation to social and life scientific factors. This question is one of the most fundamental questions for social scientists but has not yet been addressed systematically in the existing literature. We intend to address the question by means of the determinants of individual social capital. The second is to measure risk attitudes, which are expected to serve as a major determinant for one's healthcare and state of health itself. Measuring one's risk attitude is a difficult task and, in our survey, we address this question from different angles. In addition, we intend to measure economic and personal attitudes towards happiness and fairness. The answers to all the questions can be quantified so that we may select as independent and/or dependent variables.

3.1 Individual and Family Characteristics

Our survey covers a respondent's objective characteristics relating to family, education, and job.

1. **Gender and age**: Gender and age are basic characteristics that are collected in the original *Nagahama Study*. Figures 1 and 2 summarize data. As Fig. 1 shows, female respondents in our survey constitute a larger fraction than the

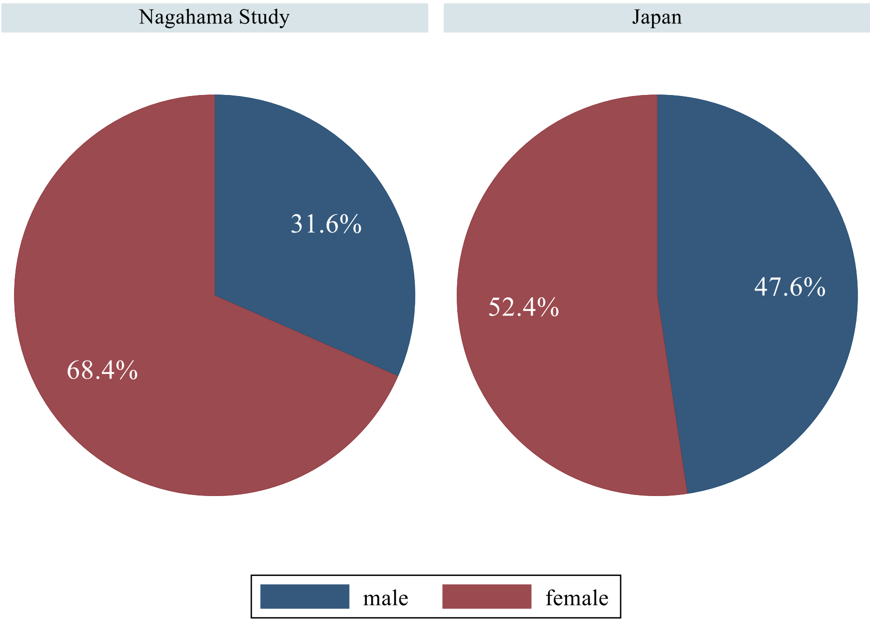

Fig. 1 Gender composition

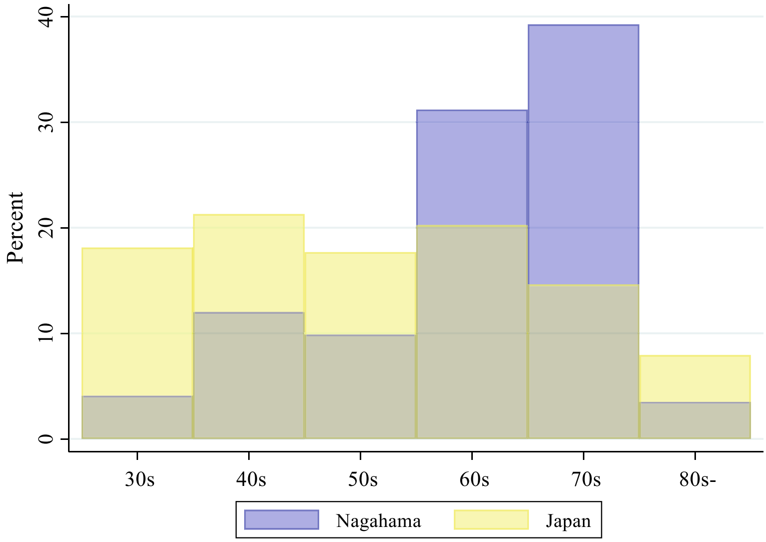

Fig. 2 Age composition (male), comparison with entire Japan

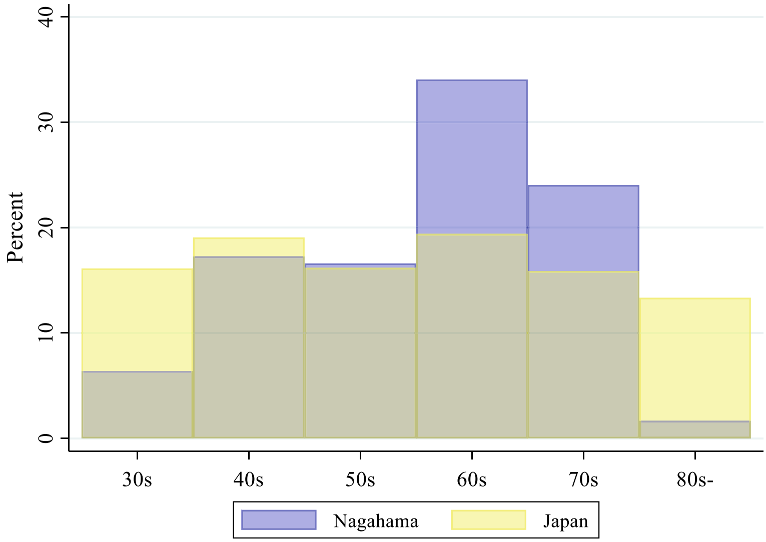

Fig. 3 Age composition (female), comparison with entire Japan

entire Japanese population based on the 2015 census. As Figs. 2 and 3 show, for both males and females, people in their 60 and 70 s are over-represented in our survey relative to the entire population. This bias is likely to be attributable the fact that the *Nagahama Study* is based on voluntary participation and tied to free health checkups provided by Kyoto University medical staff. It is intuitively clear that people in their 60 and 70 s are more health conscious and are more inclined to participate in a survey. The higher female participation, shown in Fig. 1, is consistent with our intuition; for example, the 2019 Mejji-Yasuda Life Insurance Survey reports that 62.8% of female participants say that they are carefully observing their health, while the fraction falls to 57.6% for the male participants (see Meiji-Yasuda Life Insurance Company 2019).

2. **Family**: We ask if a respondent lives with children of different age groups: preschool, elementary and middle school, high school, after high school, employed, and others including home making and being unemployed (Q1). We also ask if a respondent lives with his/her parent or his spouse's parent (Q2). As Fig. 4 shows, around one quarter of the participants live with parents (including parents in law). Moreover, we ask about the number of grandchildren a respondent has (Q3) and if he lives with any of the grandchildren (Q4); see Figs. 5 and 6.

3. **Education**: As for education, we ask the type of school a respondent last graduated from (Q6) and the year in which he graduated (Q7). The alternatives for an answer are: (1) primary school; (2) middle school; (3) high school; (4) undergraduate college; (5) graduate school; (6) two-year college; (7) technical college;

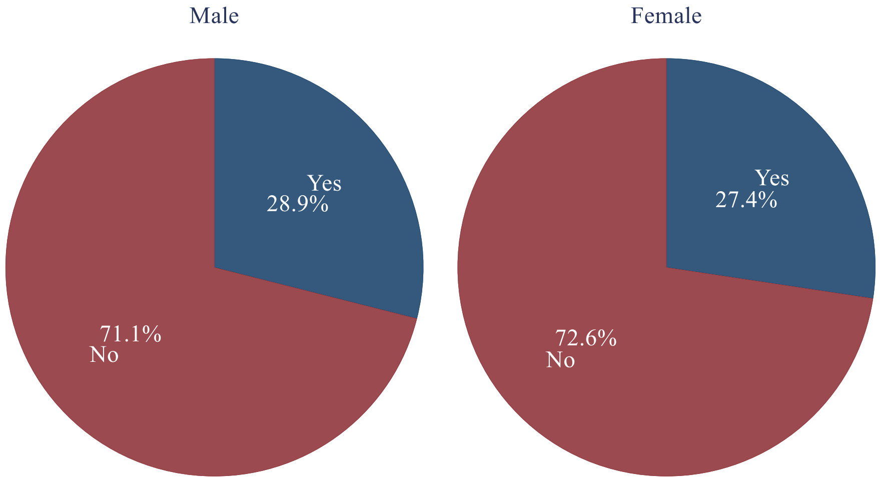

Fig. 4 Whether they live with their parents (Q2)

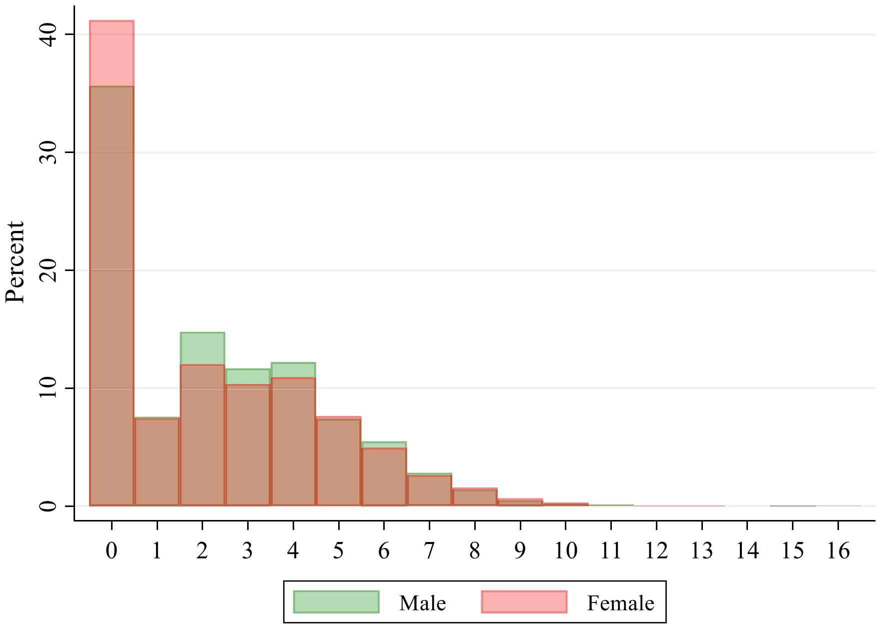

Fig. 5 Number of grandchildren (Q3)

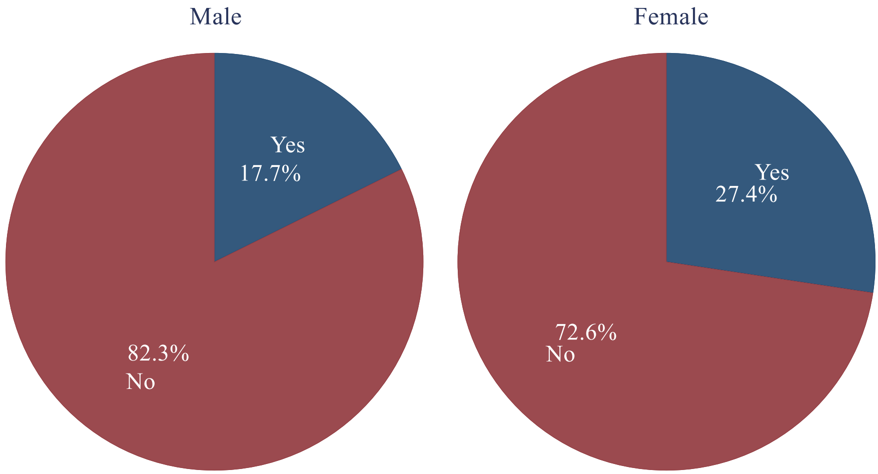

Fig. 6 Whether they live with their grandchildren (Q4)

(8) higher technical college; (9) do not want to answer. We also ask a respondent with an undergraduate or graduate degree to specify the field of specialization (Q6-1). The alternatives for an answer are: (1) literature; (2) education; (3) law; (4) economics; (5) science; (6) medicine or dentistry; (7) pharmacology; (8) engineering; (9) agriculture; (10) others. Figures 7 and 8 illustrate the distributions of highest degrees and majors for college graduates. For both men and women, as Fig. 7 shows, high school graduates constitute the highest fractions, which is consistent with the Japanese population.[1] In contrast, the fraction of those with a four-year college degree is much smaller in the Nagahama group than the entire Japanese population. Women with a four-year degree constitute a smaller fraction, while those with a two-year college degree constitute a larger fraction. Figure 8 summarizes the majors of those who have a college degree and a higher.

4. **Job**: The survey covers a respondent's job. We ask the number of weekly hours in which a respondent work to earn income (Q10). We also ask the type of employment that a respondent has (Q8). The alternatives for an answer are: (1) not employed (full time housewife, students, and retirees); (2) employee; (3) self-employee (food services, shop owners, farmers, etc.); (4) independent professionals (physicians, lawyers; accountants, tax accountants, writers, etc.); (5) family worker; (6) household worker not formally employed; (7) contract worker or subcontractor not formally employed; (8) do not want to answer. If the respondent is an employee, we ask about his job description (Q8-1). The alternatives for an answer are: (1) full-time employee below a manager level; (2) full-time employee at a manager level; (3) full-time employee at an executive

[1] Data for the Japanese population are taken from the Ministry of Internal Affairs and Communications, "Employment Status Survey 2017.".

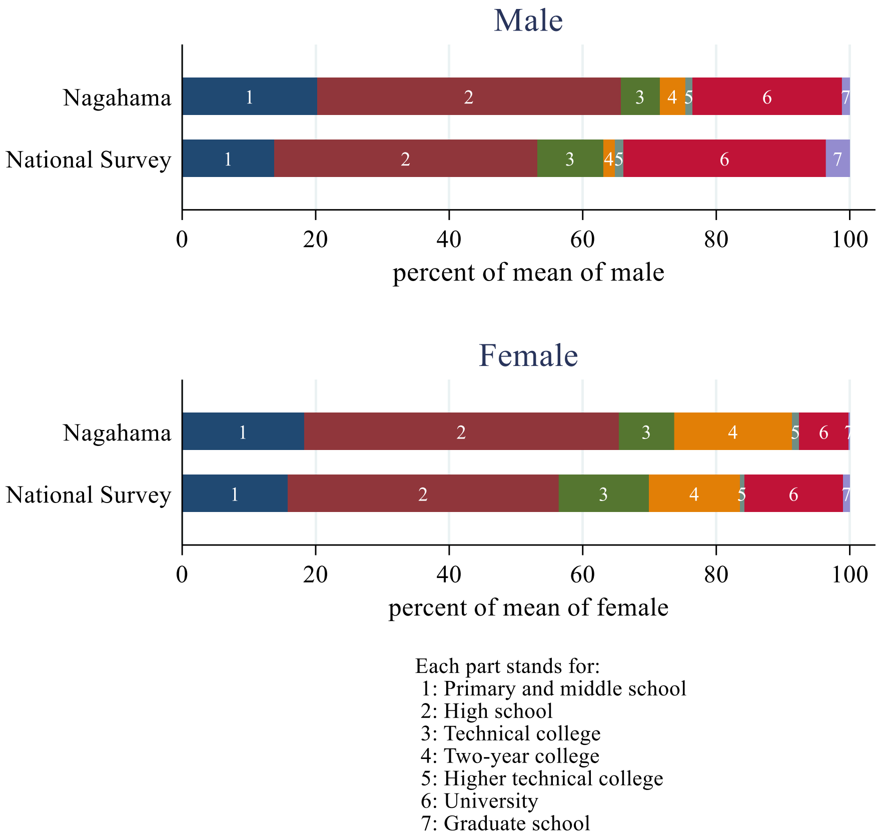

Fig. 7 Education (Q6)

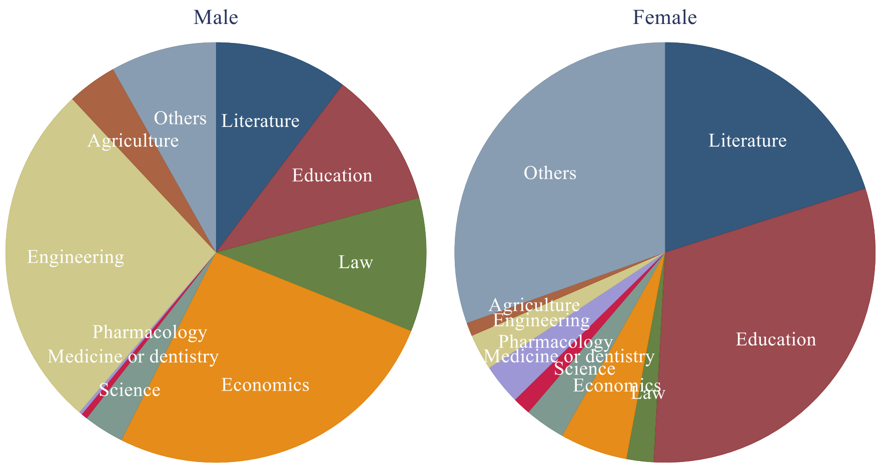

Fig. 8 Major (Q6-1)

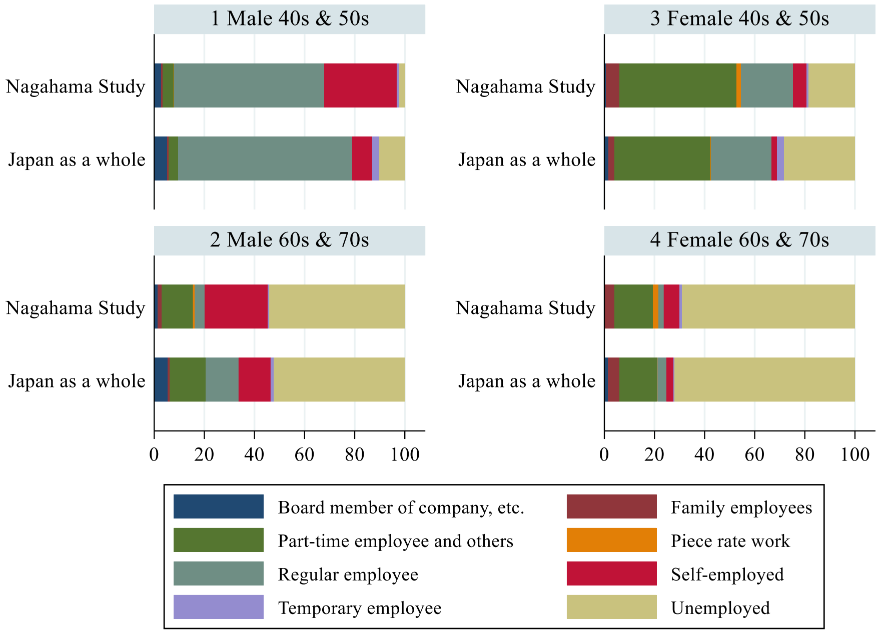

Fig. 9 Types of job (Q8 and Q8-1)

level; (4) contract employee; (5) temporary or part-time worker; (6) dispatched worker; (7) commissioned worker; (8) do not want to answer. Figure 9 illustrates the distribution of job types for our survey samples and for Japan as a whole. In this figure, those who do not want to answer are dropped. For both men and women in their 40 s and 50 s, the fraction of people who have a job is higher than the Japanese population. The fraction of men who have a full-time job is smaller in the Nagahama group; the fraction of women who have a part-time job is larger. A larger fraction of people are self-employed in the Nagahama group than the Japanese population. In contrast, the percentage of regular employees is lower. In addition, females in their 40 s and 50 s are also characterized by a high proportion of part-time employees and others. We also ask the kind of job that a respondent performs (Q9). The alternatives for an answer are: (1) agriculture, forestry, and fishery; (2) mining; (3) sales; (4) service provider; (5) administrative and managerial; (6) clerical; (7) transportation or communication; (8) manufacturing, construction, maintenance, moving and delivery business; (9) data processing and system engineering; (10) specialized or technical work other than those in (9), healthcare, personnel, legal staff, teachers, artists (11) security (self-defense force, police, fireman, security guard); (12) do not want to answer. Figure 10 illustrates the distribution of kinds of jobs for our survey samples and for Japan as a whole; because the job types in our questionnaire are finer than in the census, we adjust our job types to that of the census. For both males and

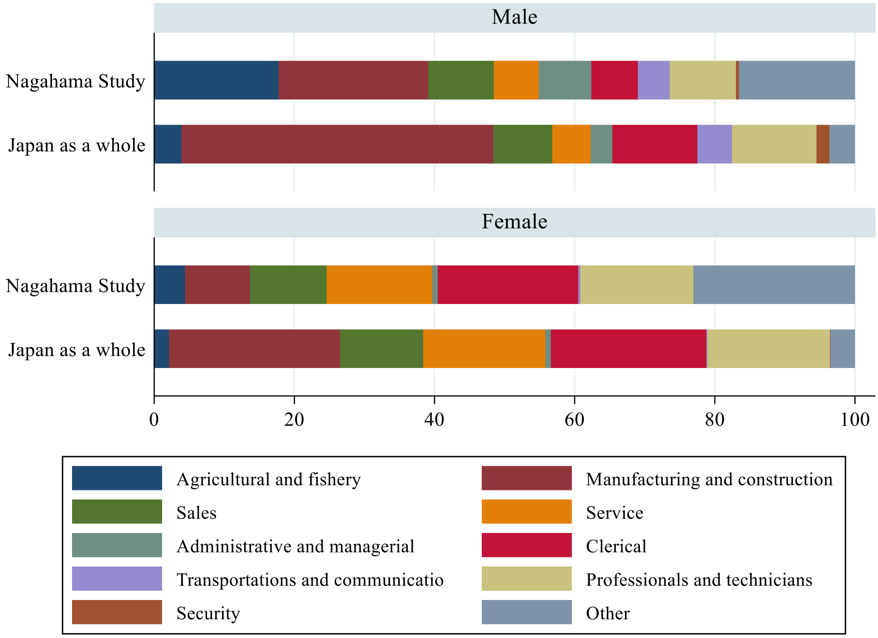

Fig. 10 Kinds of job (Q9)

females, the share of agriculture, forestry, and fishery work is high and that of manufacturing is low compared with the entire Japan.

5. **Financial state:** In order to explain personal views on life and the states of health, it is important to control income and financial assets. For this reason, we first ask a respondent's yearly household income as well as personal income (Q11, Q13). The alternatives for an answer on these questions are: (1) 0–2 m yen; (2) 2–4 m yen; (3) 4–6 m yen; (4) 6–8 m yen; (5) 8–10 m yen; (6) 10–15 m yen; (7) more than 15 m yen; (8) do not want to answer. We also ask about a respondent's household total assets as well as personal total assets, including bank deposits, shares and mutual funds (Q12, Q13). The alternatives for an answer on these questions are: (1) 0–2 m yen; (2) 2–4 m yen; (3) 4–6 m yen; (4) 6–8 m yen; (5) 8–10 m yen; (6) 10–15 m yen; (7) 15–20 m yen; (8) more than 20 m yen; (9) do not want to answer. The upper panel of Fig. 11 shows the distributions of annual income for male and female (Q13). For each age groups of men and women, the lower panels show the relationship between each income level and the percentage of people who are in that income level or lower (cumulative relative frequency curves). For example, the heights of orange lines at 2 show that about 90% of people in their 70 s have income less than or equal to 4 m yen. Figure 12 shows the individual assets of participants (Q14). The upper panel shows that the fraction of women with personal assets of 2 m yen or less is higher than that of males. In the lower panels, the cumulative

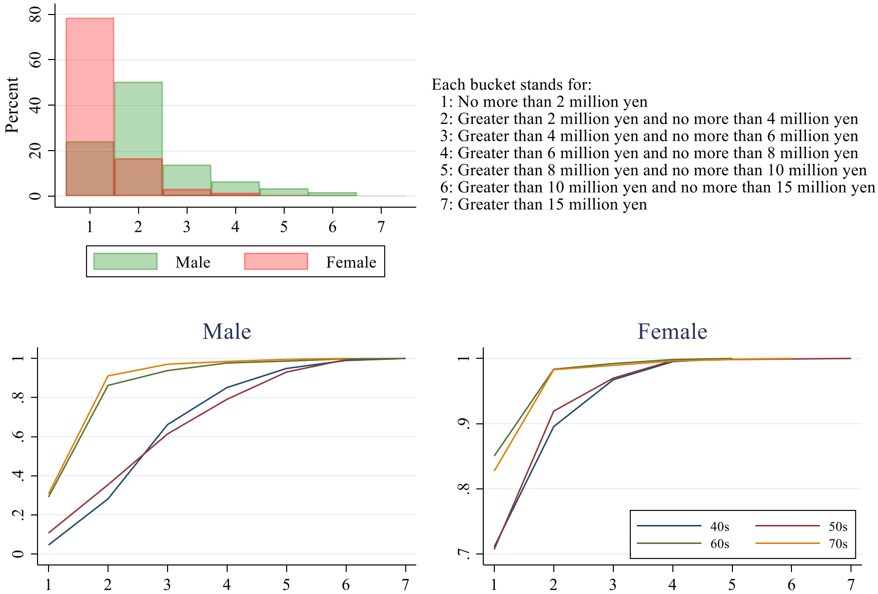

Fig. 11 Individual income (Q13)

Fig. 12 Individual assets (Q14)

frequency curves by age group shifts downward in the order of 40 s, 50 s, 70 s, and 60 s for both males and females, which implies that many people reduce their assets most when they are in their 60 s.

3.2 Social Capital

In the first *Nagahama Survey*, we ask 13 questions relating to social capital. The questions can be classified into one of the OECD's four types of social capital: (1) personal relationships; (2) social network support; (3) civic engagement; (4) trust and cooperative norms (see Scrivens and Smith (2013) and Yodo and Yano (2017, 2021)). Some of the questions related to social capital are taken from the *Survey on Security, Trust, and Social Participation in Daily Life* (2013) conducted by Yoji Inaba (the *Inaba Survey*). Unlike our *Nagahama Survey*, the *Inaba Survey* covers the entire country.[2] In what follows, we compare our survey results with those in the *Inaba Survey* to show differences between Nagahama participants and Inaba participants, the latter of whom represent Japan as a whole.

1. **Personal relationships**: To measure the amount of social capital representing personal relationships, we ask how often an individual interacts with his neighbors (Q33). The alternatives for an answer are: (1) I have someone with whom I cooperate in my daily life, for example, by giving each other advice or loaning each other daily necessities. (2) I associate with some neighbors by regularly chatting with them. (3) I only associate with them at the minimum level of exchanging greetings. (4) I do not associate with them at all. As shown in the first panel of Fig. 13, the answers are not very different between men and women. The lower panels show that the older the age group, the higher the degree of closeness to neighbours. It can also be seen that such a change in distribution occurs more gradually in females; it occurs rapidly between their 40 s and 50 s in males. Figure 14 compares the Nagahama respondents with the Japanese population represented in the *Inaba Survey*. It shows that the Nagahama respondents have closer relationship with neighbours than the average Japanese. Another question is how many of his neighbours a respondent interacts with on friendly term (Q34). The alternatives for an answer are: (1) 20 or more; (2) 5–19; (3) 4 or less; (4) I do not know who lives next door. Figure 15 illustrates the distribution of answers to this question. As shown in the upper panel, the percentage of people who have more contacts with neighbours is higher for men than women. As the lower panels show, the older they are, the more neighbors they associate with. Figure 16 shows the distributions of answers for the *Nagahama Study* and the *Inaba Survey*. We can see that the participants in the *Nagahama Study* have closer relationships with neighbours than the average Japanese people. Moreover, we ask how often a respondent usually interacts with people in each of the following groups: friends and acquaintances, relatives, and workmates

[2] See Inaba (2014) for details.

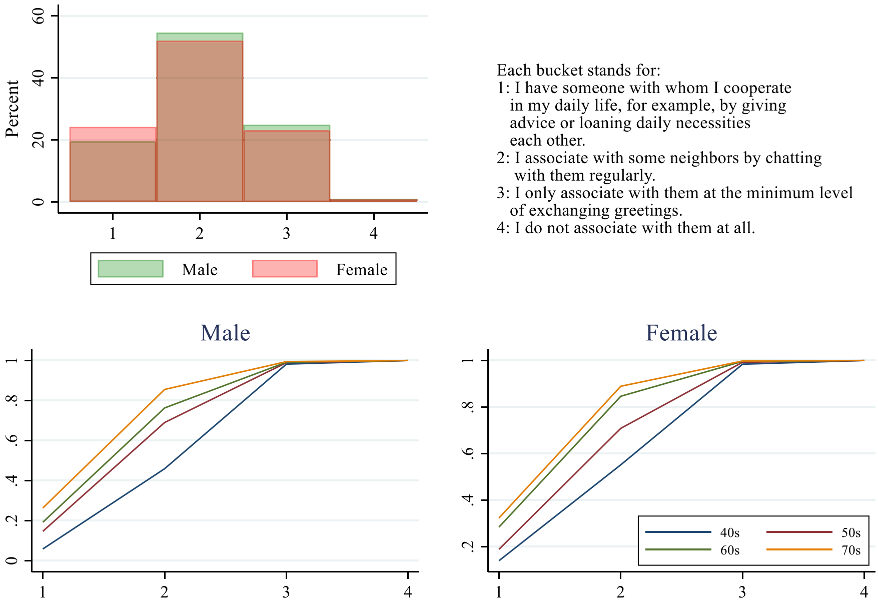

Fig. 13 Interaction with neighbors (Q33)

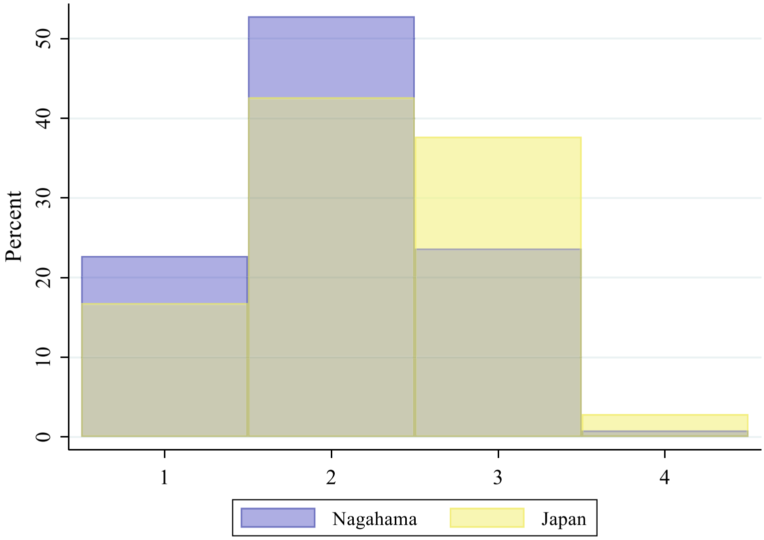

Fig. 14 Interaction with neighbors (Q33), comparison with entire Japan

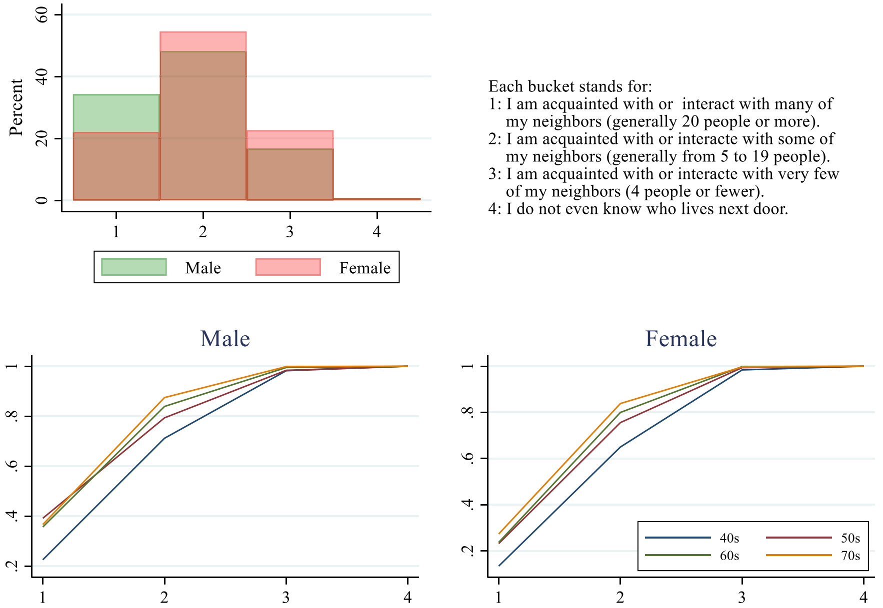

Fig. 15 Number of close neighbors (Q34)

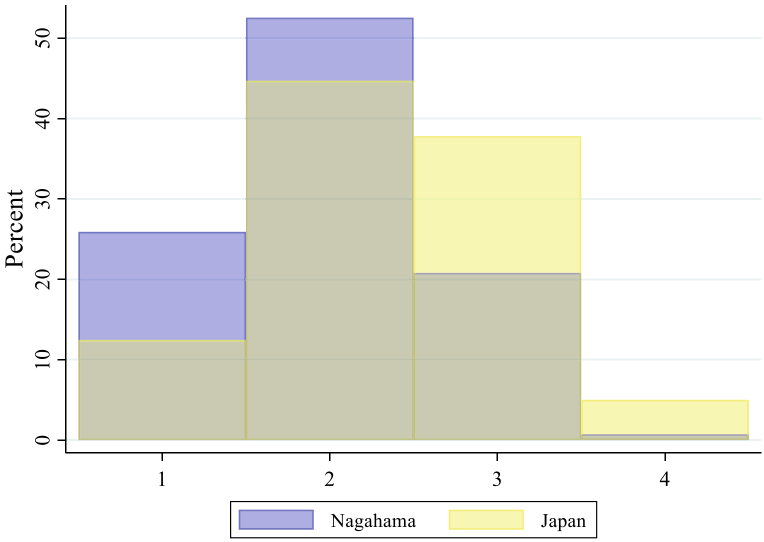

Fig. 16 Number of close neighbors (Q34), comparison with entire Japan

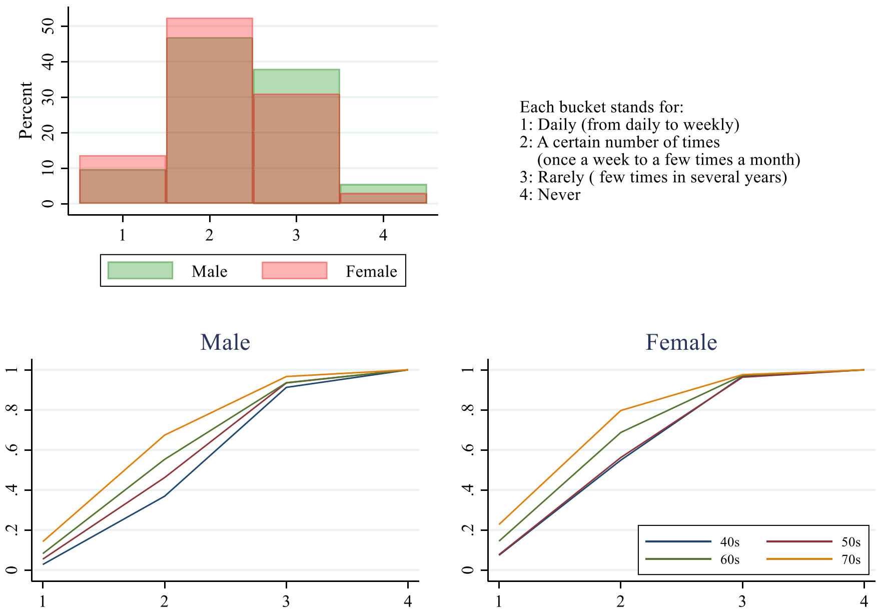

Fig. 17 Frequency of interaction (friends) (Q37-1)

(Q37). The alternatives for an answer are: (1) daily; (2) from once a week to a few times a month; (3) from once a year to a few times in several years; (4) never. Figures 17, 18 and 19 show the distributions of answers to these questions. Answers to the questions relating to friends and acquaintances and to relatives are similar to those relating to neighbours. In contrast, answers to the question relating to workmates are significantly different from those relating to friends and acquaintances, and relatives; people maintain looser relationships with workmates.

2. **Social network support**: To measure the amount of social capital representing social network support, we ask the extent to which a respondent thinks he can count on people in each of the following groups: neighbours, family members, relatives, friends and acquaintances, and workmates to seek for help to deal with daily problems and concern (Q35). The alternatives for an answer are: (1) very much; (2) somewhat; (3) cannot say either way; (4) not very much; (5) not at all. Moreover, we ask if a respondent wants his children and grandchildren to continue to live in the region where he currently lives (Q39). The alternatives for an answer are: (1) yes; (2) no, and (3) I do not know. With neighbours, family members, relatives and workmates, the Nagahama respondents maintain closer ties than the average Japanese. With friends, they are not very different from the average Japanese. The upper panels of Figs. 20, 21, 22, 23 and 24 compare the distributions of answers between men and women, which are similar to each other. As the figures show, the distributions of answers to

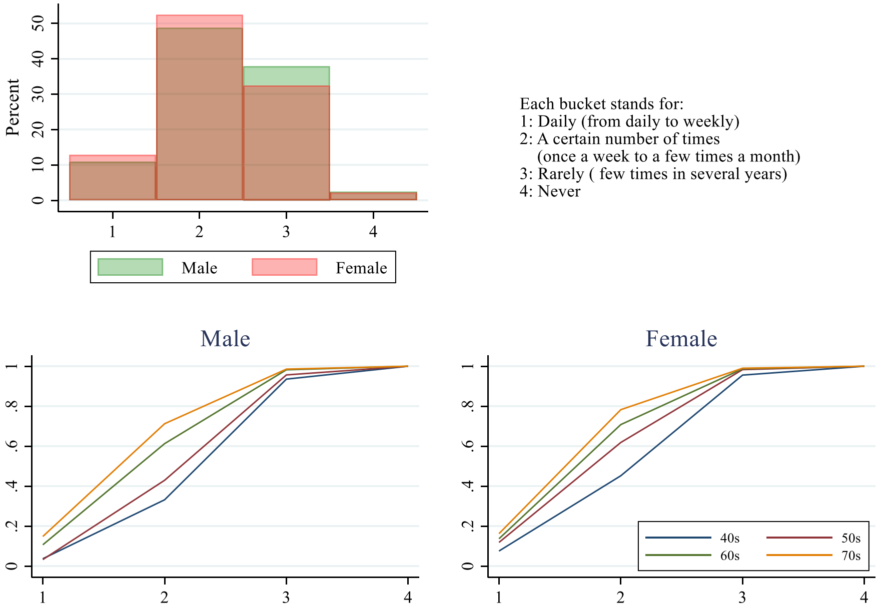

Fig. 18 Frequency of interaction (relatives) (Q37-2)

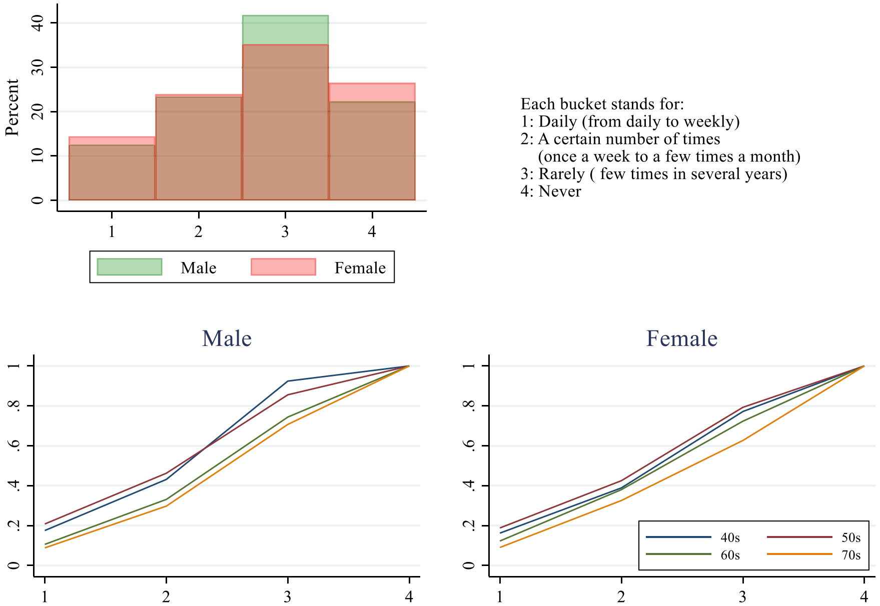

Fig. 19 Frequency of interaction (workmates) (Q37-3)

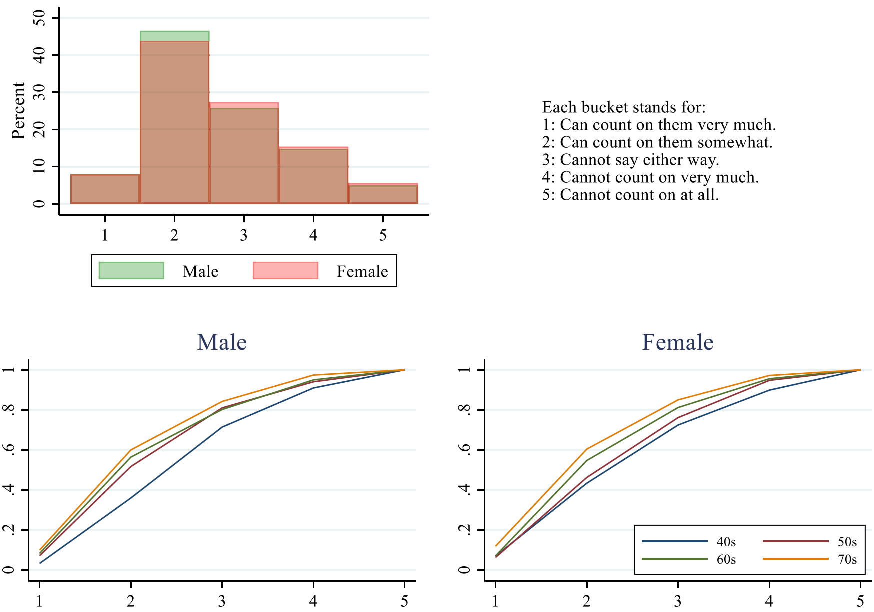

Fig. 20 Those who you can count on (neighbours) (Q35-1)

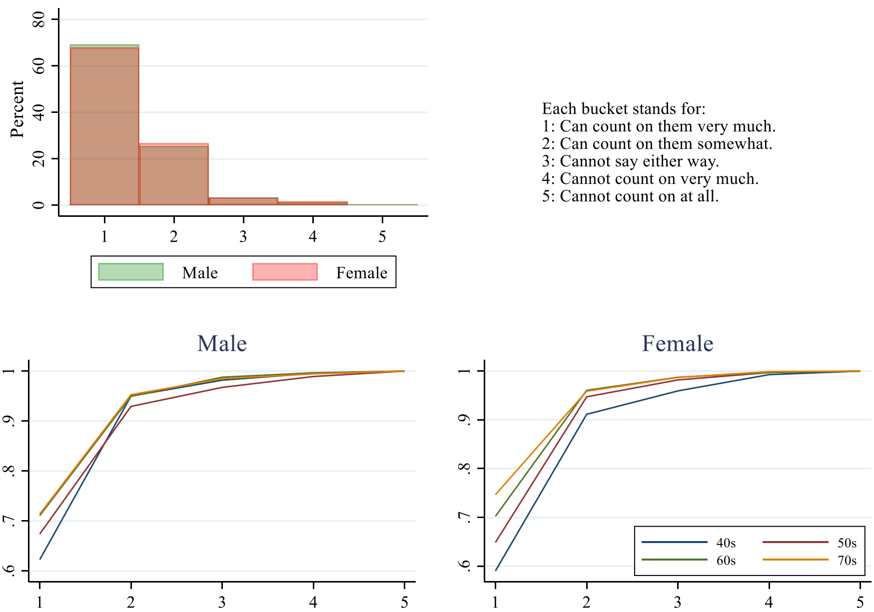

Fig. 21 Those who you can count on (family members) (Q35-2)

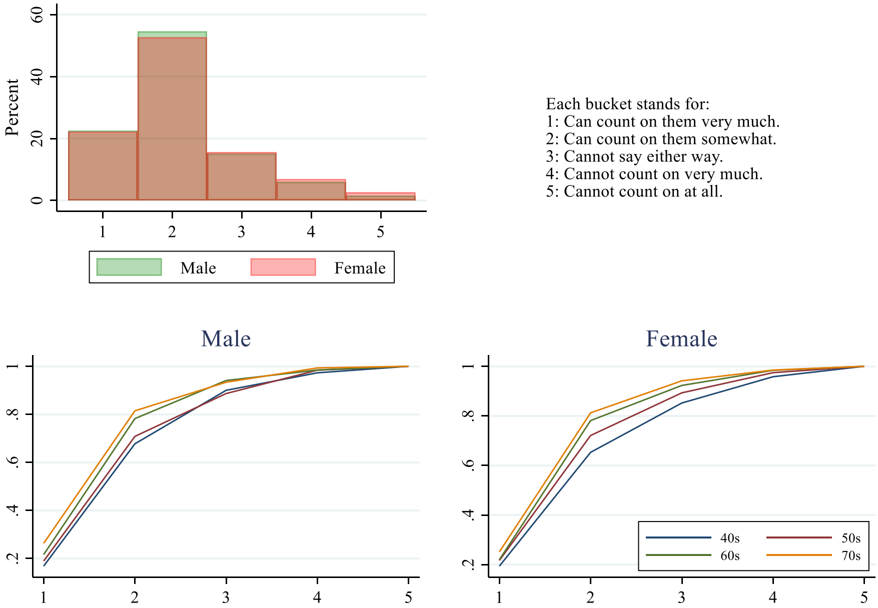

Fig. 22 Those who you can count on (relatives) (Q35-3)

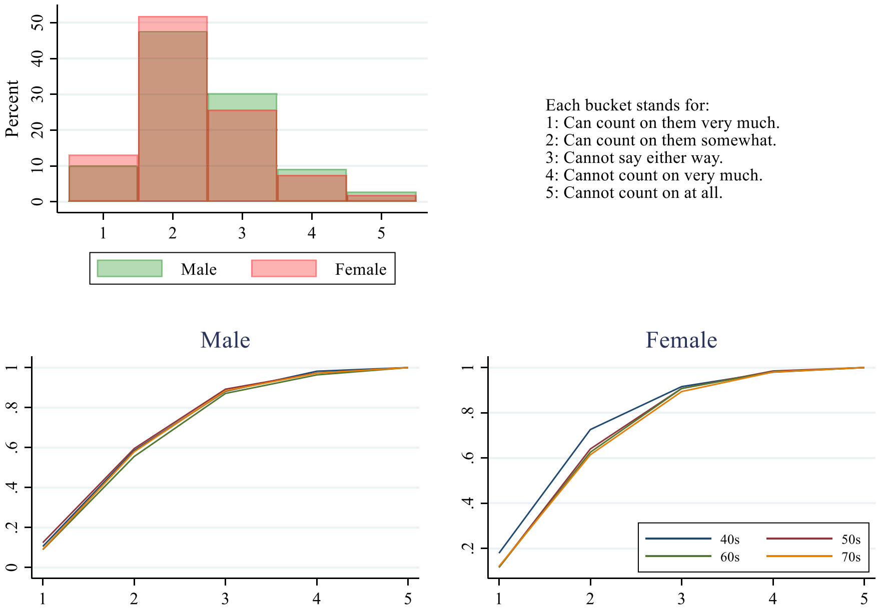

Fig. 23 Those who you can count on (friends) (Q35-4)

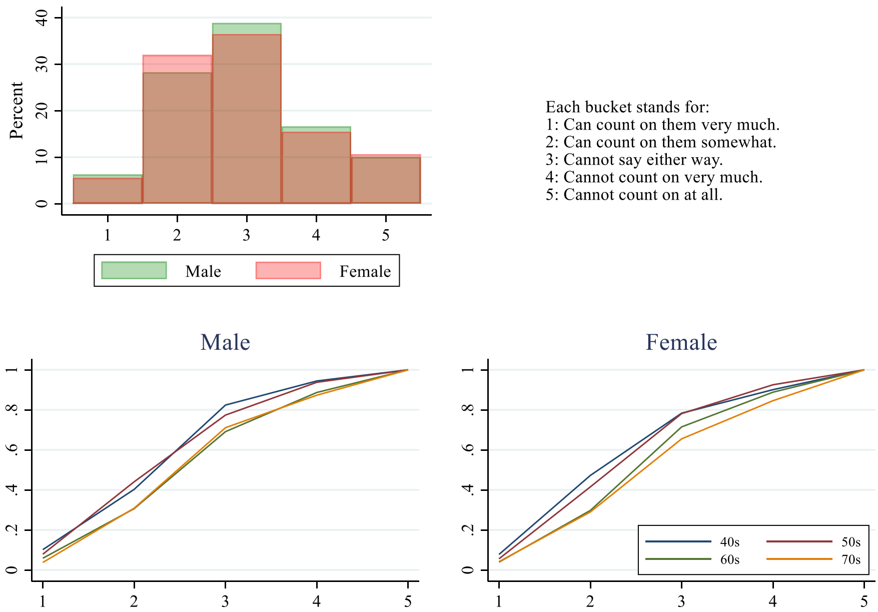

Fig. 24 Those who you can count on (workmates) (Q35-5)

Q35 is much the same as those concerning personal relationship with respect to neighbours. In contrast, with respect to friends, the distribution of answers to the questions concerning social network support do not vary across age groups. This is more clearly so for men. More women in their 40 s, in contrast, have friends whom they can count on very much than those in other age groups. (This may be because they may have a strong network built through childcare activities.) Moreover, young people appear to have more workmates whom they can count on than older people. This is likely because more old people are retired than young people. Figure 25 shows the distributions of answers for *Nagahama* and *Inaba Surveys*. With respect to friends and workmates, on the one hand, the distributions are similar to each other. On the other hand, Nagahama participants tend to have closer ties with neighbours, family members and relatives than the Japanese people as a whole.

3. **Civic engagement**: In order to measure the amount of social capital representing civic engagement, we ask if a respondent participates in each of the following activities: local community activities, sports, hobbies, and recreational activities, volunteer, NPO, and civic activities, and activities in other types of organizations (Q38). The alternatives for an answer are: (1) almost every week; (2) about two or three days in a month; (3) about one day per month; (4) a few times a year; (5) I am not active. We also measure an individual's social capital relating to civic engagement by asking his willingness to contribute to the society an individual belongs to. That is, we ask if a respondent is willing to contribute

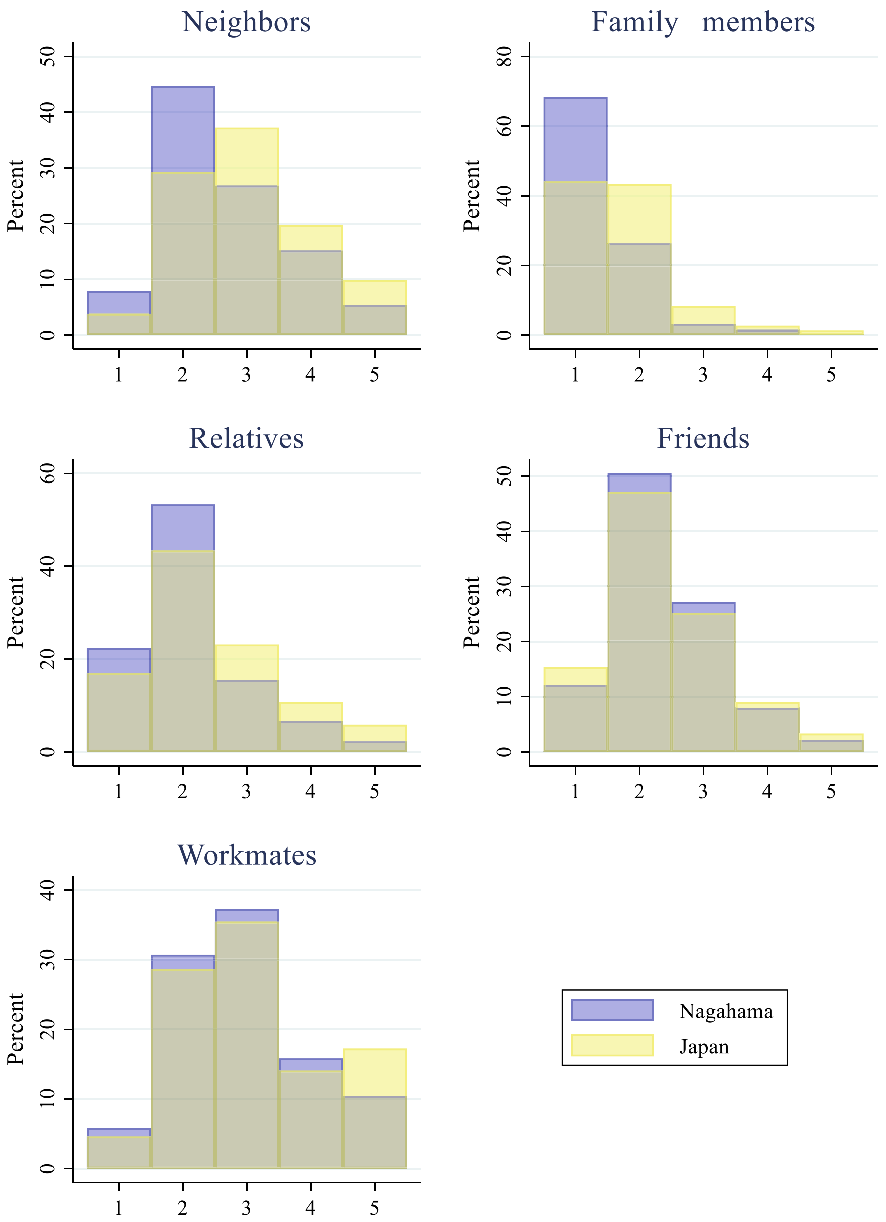

Fig. 25 Those who you can count on (Comparison with Entire Japan) (Q35)

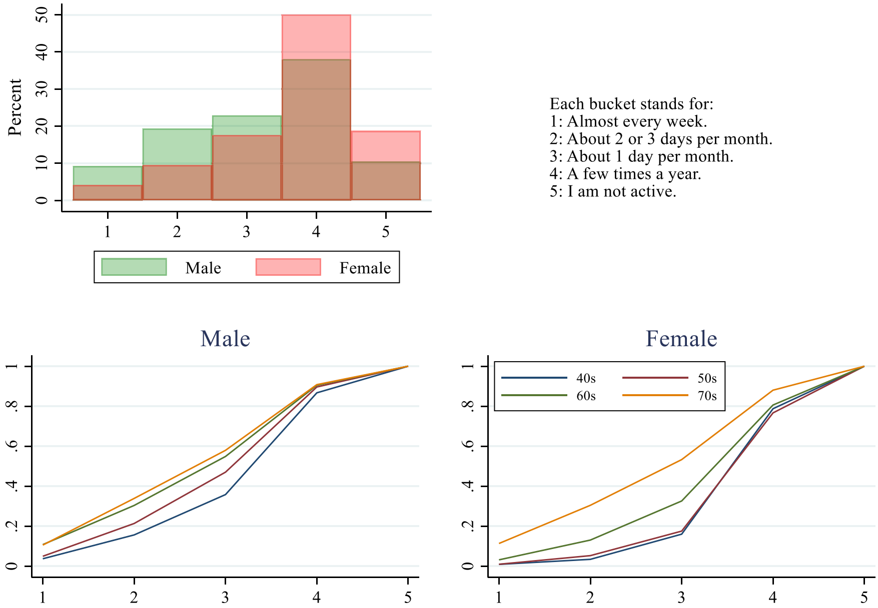

Fig. 26 Participation in community activities (Q38-1)

to fixing community problems, such as the decline of a local shopping street, an increase in abandoned land and housing lots, and local childcare activities (Q40). The alternatives for an answer are: (1) yes; (2) yes, if possible; (3) not very much; (4) not at all; (5) I do not know. We ask if a respondent have donated money to a NPO or an organization conducting charitable activities during the past year (Q36). The alternatives for an answer are: (1) none; (2) 1–999 yen; (3) 1,000–4,999 yen; (4) 5,000–9,999 yen; (5) 10,000–49,999 yen; (6) more than 50,000 yen. Figure 26 shows that men tend to participate in community activities more than women. As Figs. 28 and29 show, people who do not participate in voluntary and other activities are more than those who do. As Fig. 27 shows, in contrast to abovementioned activities, people are divided into groups who are strongly committed and are not at all interested. Figure 30 shows the distributions of answers for *Nagahama* participants and for Japanese people as a whole.[3] The distributions are not very different with respect to recreational activities, volunteer activities, and other activities. In contrast, more people in the *Nagahama Survey* participate in community activities than Japanese people as a whole. Figure 31 shows that people are not strongly willing to make donations,

[3] Since the alternatives in the *Inaba survey* are different from those in the *Nagahama Study*, the alternatives in the *Inaba survey* are recombined to be consistent with those in the *Nagahama Study* for this comparison.

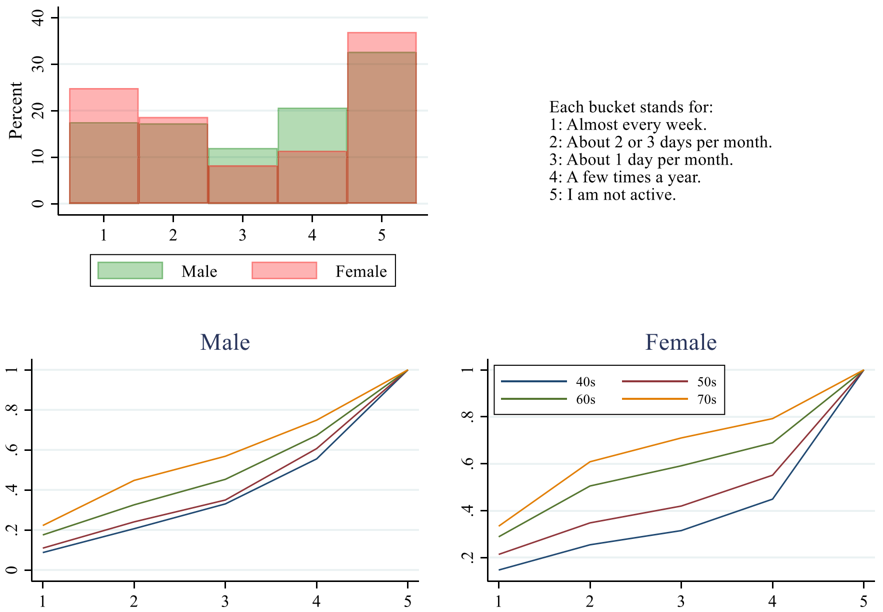

Fig. 27 Participation in recreational activities (Q38-2)

which is a usual characteristic of Japanese people as Fig. 32 shows.[4] With respect to the willingness to contribute to fixing community problems, very few people are either unwilling or willing strongly. Young people and old people are not so different: see Fig. 33. We also measure an individual's trust in various social institutions. That is, we ask to what extent a respondent trusts the National Diet, the government, local governments, courts, police, and financial institutions (banks, securities companies, etc.) (Q41). The alternatives for an answer are: (1) strongly yes; (2) somewhat yes; (3) cannot say either; (4) not very much; (5) not at all; (6) I do not know. As Figs. 34, 35, 36, 37, 38, and 39 , show, people's trust in the National Diet and government have similar distributions. Their trust in local governments, courts, police, and financial institutions have similar distributions. These distributions are not very different across different age groups.

4. **Trust and cooperative norms**: In order to measure the amount of social capital representing trust and cooperative norms, we ask if a respondent thinks either that most people can be trusted or that he needs to be very careful in dealing with people[5] (Q30). We also ask his view on this question when he was 15 years

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[4] Since the alternatives in the *Inaba survey* are different from those in the *Nagahama Study*, the alternatives in the *Inaba survey* are recombined to be consistent with those in the *Nagahama Study* for this comparison.

[5] This question is commonly adopted in the literature on social capital. For example, it is used from the beginning of the *World Value Survey* started in 1981. See Inglehart et al. (2014) for details.

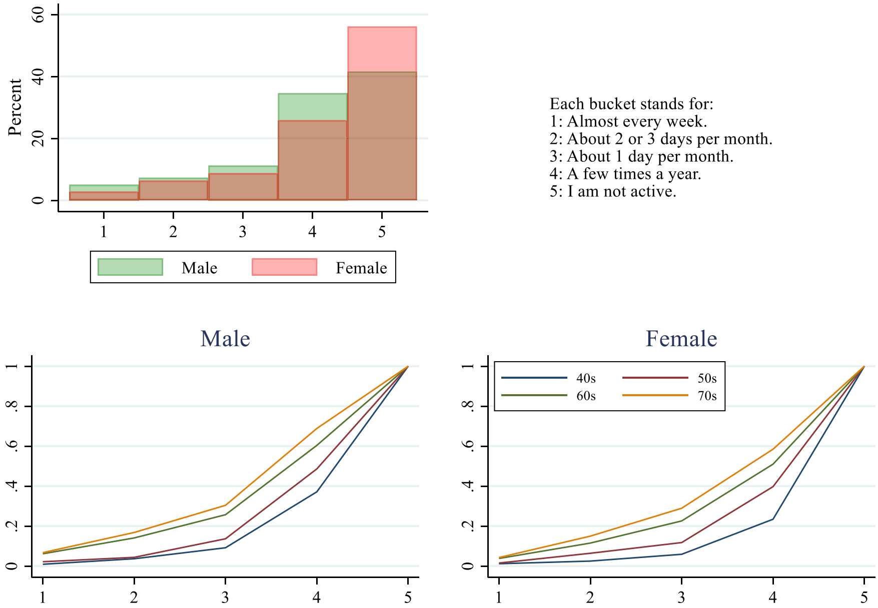


Fig. 28 Participation in volunteer activities (Q38-3)

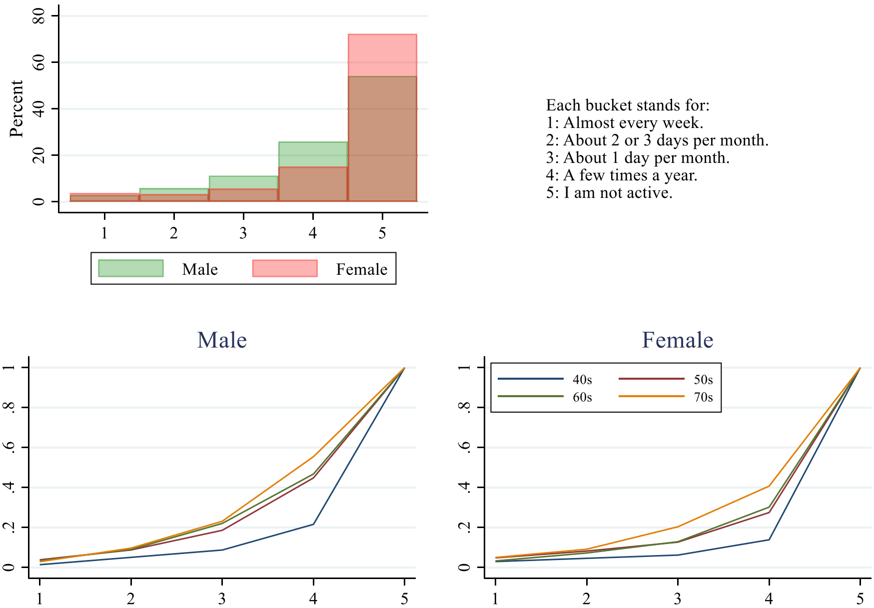


Fig. 29 Participation in other activities (Q38-4)

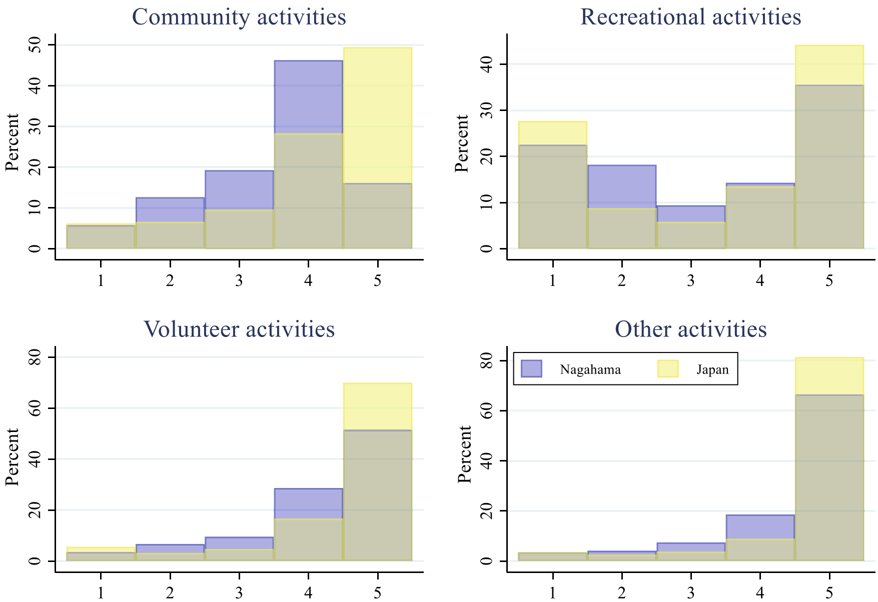


Fig. 30 Participation in various activities (comparison with entire Japan) (Q38)

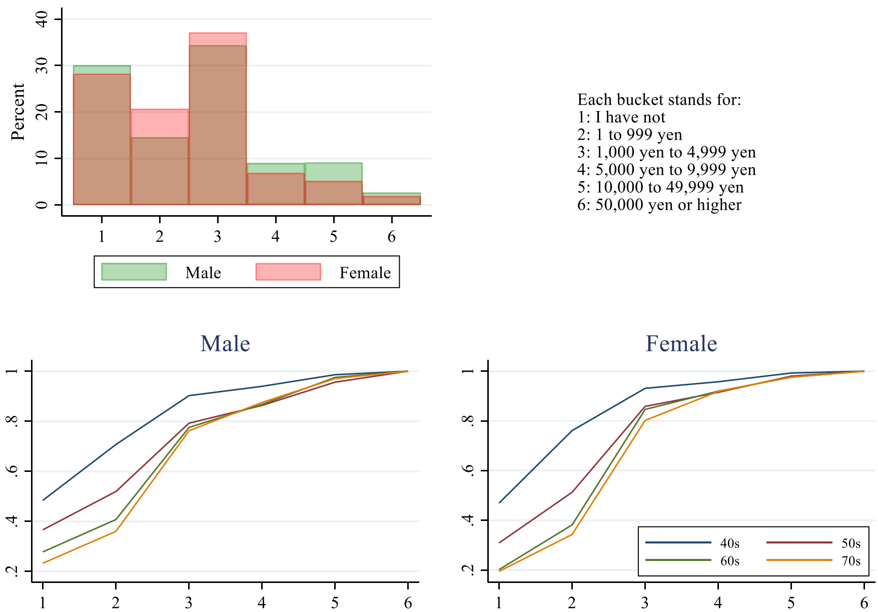


Fig. 31 Donation (Q36)

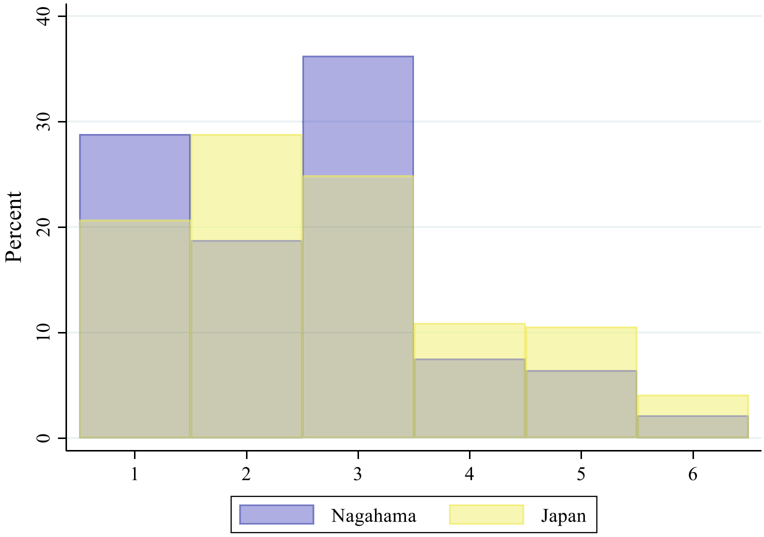


Fig. 32 Donation (Q36), comparison with entire Japan

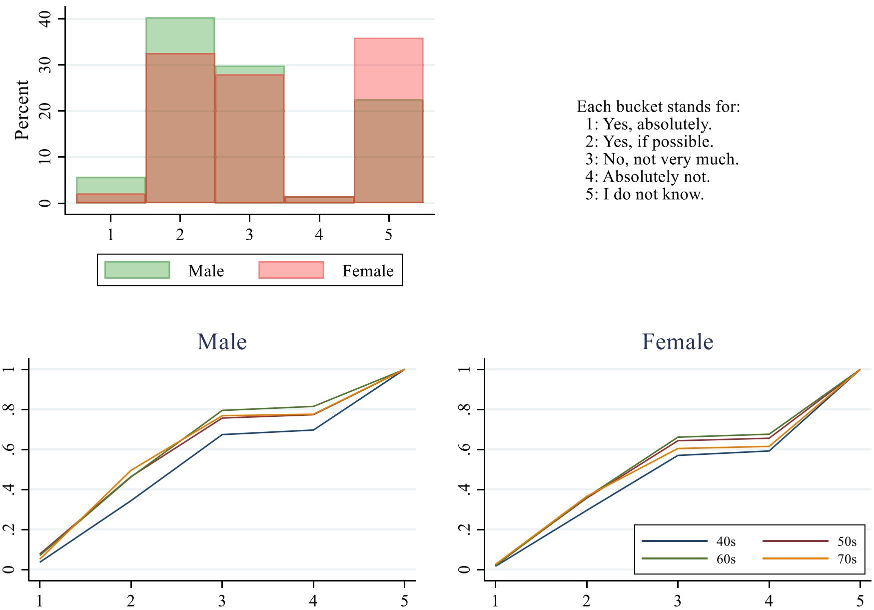


Fig. 33 Readiness to contribute to community problems (Q40)

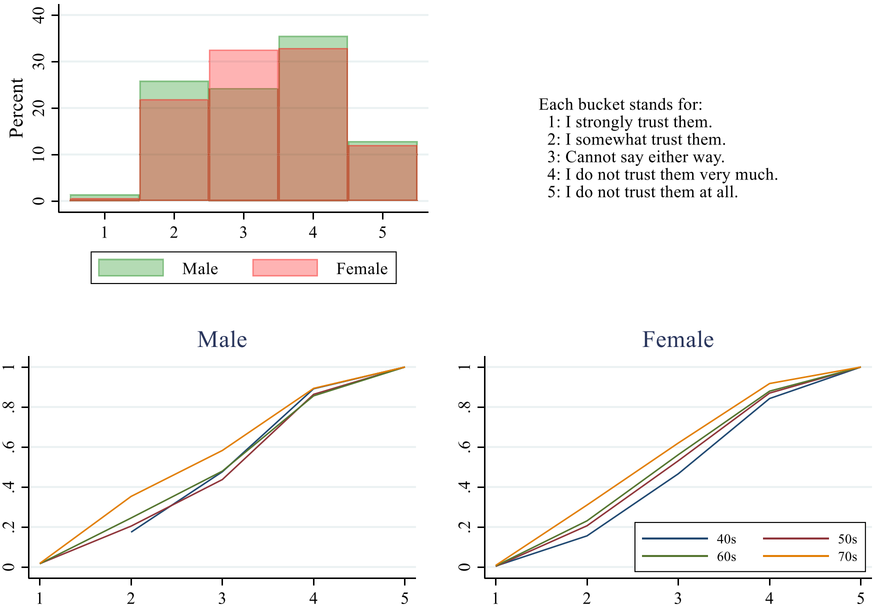


Fig. 34 Trust in the Diet (Q41-1)

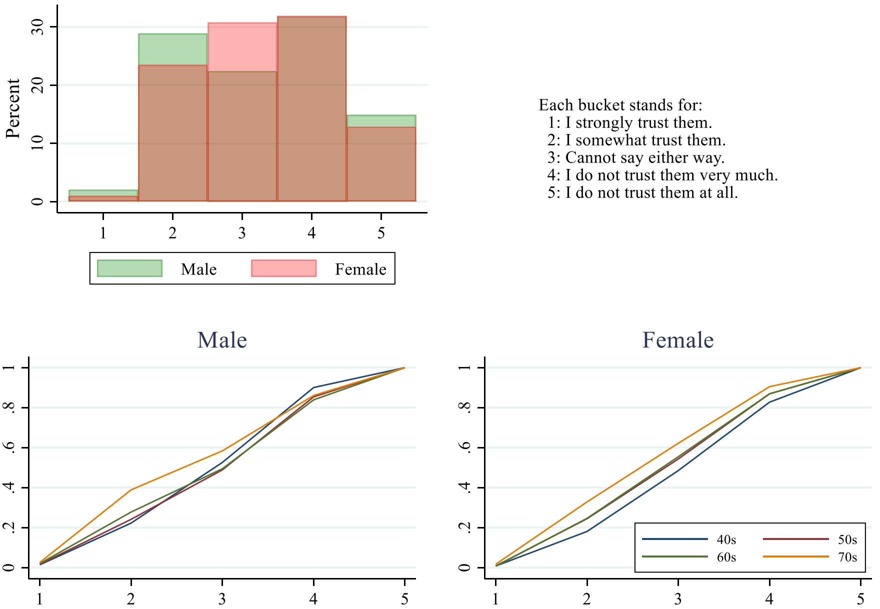


Fig. 35 Trust in the government (Q41-2)

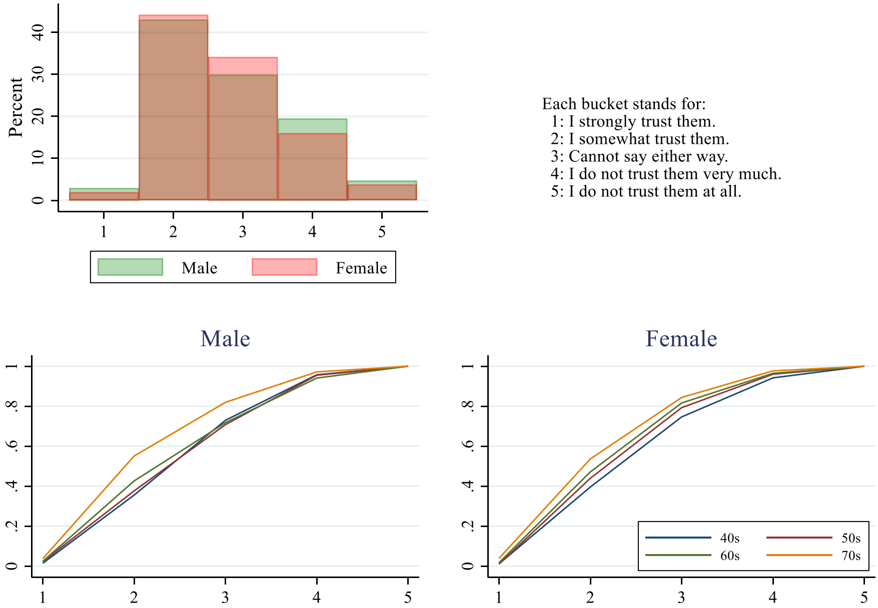


Fig. 36 Trust in local governments (Q41-3)

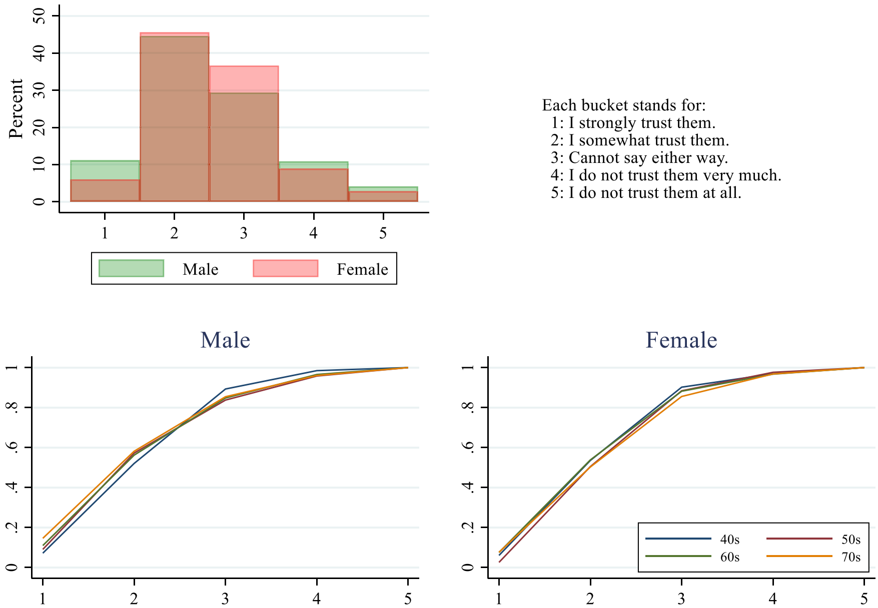


Fig. 37 Trust in courts (Q41-4)

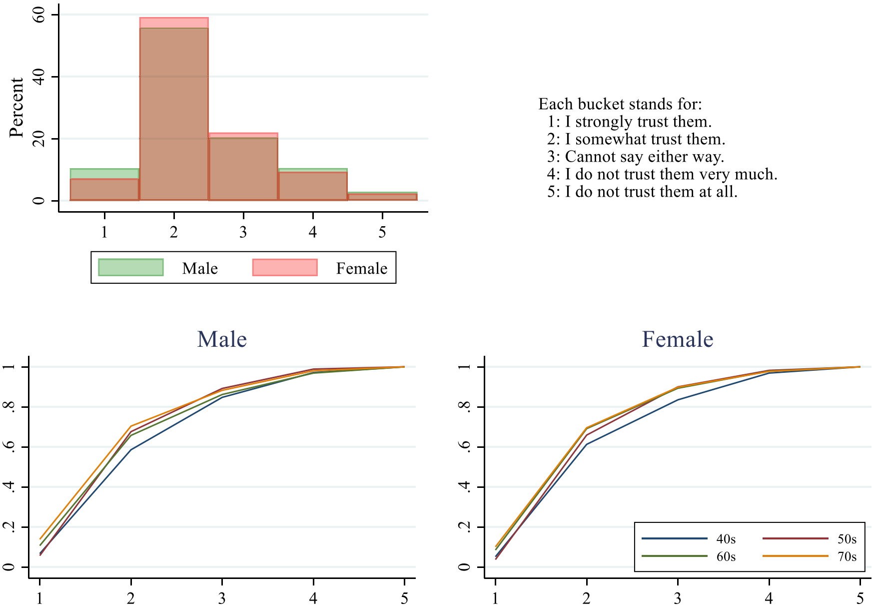


Fig. 38 Trust in police (Q41-5)

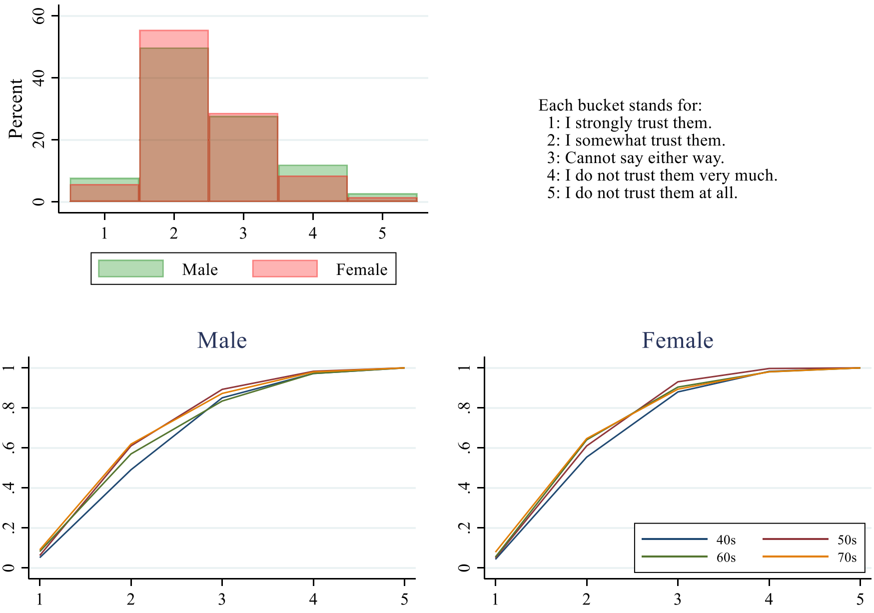


Fig. 39 Trust in financial institutions (Q41-6)

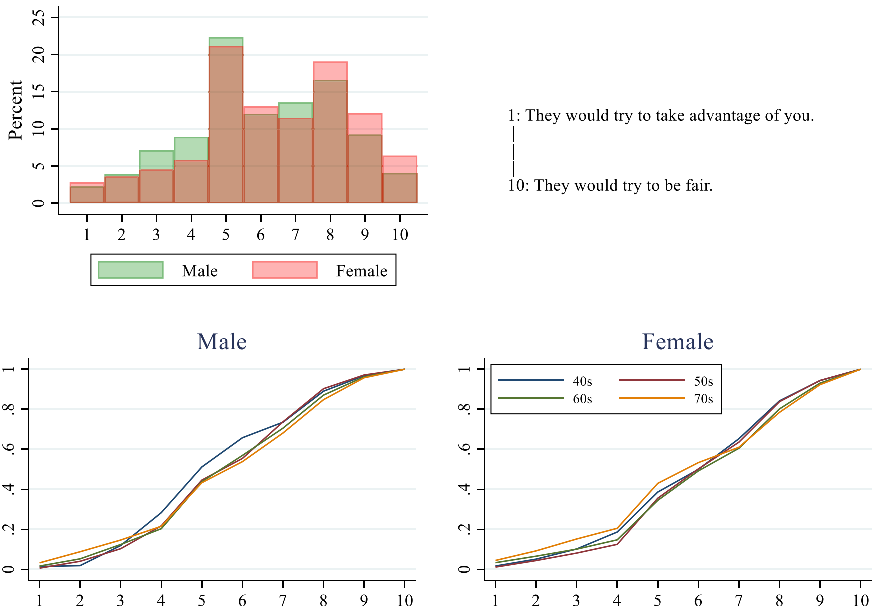


Fig. 40 General trust (Q32)

old (Q31). Similarly, we ask if a respondent thinks either that others would try to take advantage of him if they got a chance or that they would try to be fair (Q32). For these questions, respondents are asked to rate his view from 1 through 10. We also measure social capital relating to trust and cooperative norms by means of reciprocity, or a social norm rewarding a positive action by returning a positive action similar in kind. That is, we ask if a respondent agrees that if he helps out others who need help, they will help me out when he is in need of help (Q42-1). We also ask if a respondent agrees that he is willing to carry a larger burden than now in order to let future generations, including children and grandchildren, have the same standard of living and same level of public services as he is having now (Q42-2). The alternatives for an answer to these two questions are: (1) strongly yes; (2) yes; (3) cannot say either; (4) no; (5) definitely, no; (6) I do not know. As Fig. 40 shows, the distribution of answers to Q32 does not vary between men and women very much. As Figs. 40, 41, 43 and 44 show, the distributions of answers to questions Q30, Q32, and Q42 are similar. That is, they tend to trust people, to find that people do not take advantage of others, and to think that good deeds are reciprocal. These views do not vary much across age groups. Figure 42 shows the distributions of answers to Q30 for Nagahama participants and for Japanese people as a whole.[6] The

[6] For this question, the *Nagahama Study* requires an answer on a scale of 10, while the *Inaba Survey* requires an answer on a scale of 9. For this reason, the 5th and 6th alternatives in the *Nagahama Study* are combined for comparison.

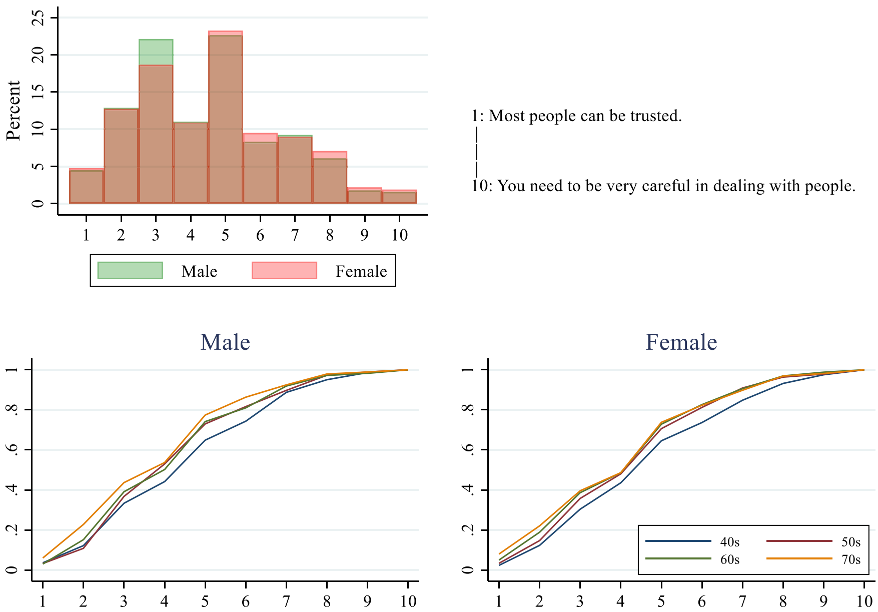


Fig. 41 General trust (Q30)

distributions are similar except that a much larger portion of Japanese people as a whole believe that others cannot be trusted at all than Nagahama participants. This may be because the Nagahama community is small and because its residents are more uniform. As Fig. 45 shows, older people think that they trust others more than when they were young. This agrees with our finding above on social capital relating personal relationships.

3.3 Attitudes Towards Risk

We intend to capture one's risk attitudes by means of a straight self-evaluation and a risk-taking activity. In addition, we measure them by means of one's tendency towards healthcare and involvement in risky asset holdings.

1. **Direct risk**: In order to capture one's self-evaluation on his risk attitudes, we ask if a respondent thinks either that he is fully prepared to take risks concerning all matters or that he always tries to avoid taking risks (Q15). A respondent is asked to rate his view from 1 to 10. We also intend to measure an individual's risk aversion by a probabilistic thought experiment. That is, we ask which of the following two lotteries a respondent prefer. The first is a lottery by which he can receive 60,000 yen without fail. The second is a lottery by which he can receive 120,000 yen with a 30% chance (Q16). Moreover, we further ask a respondent who prefers the sure lottery to specify the minimum probability with which he

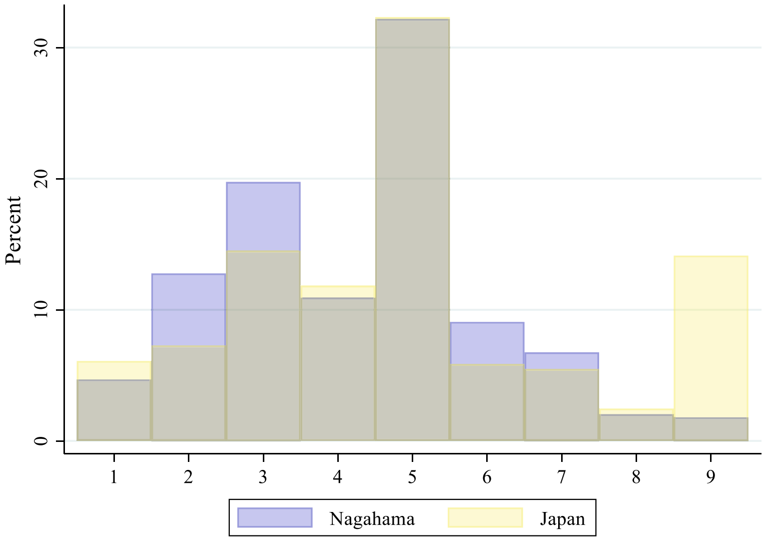


Fig. 42 General trust (Q30), comparison with entire Japan

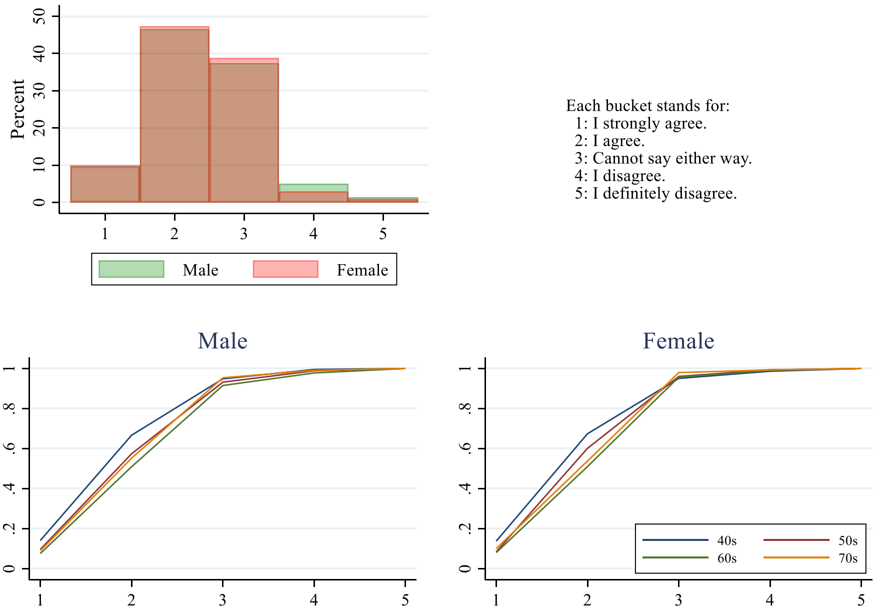


Fig. 43 Attitudes on reciprocity (Q42-1)

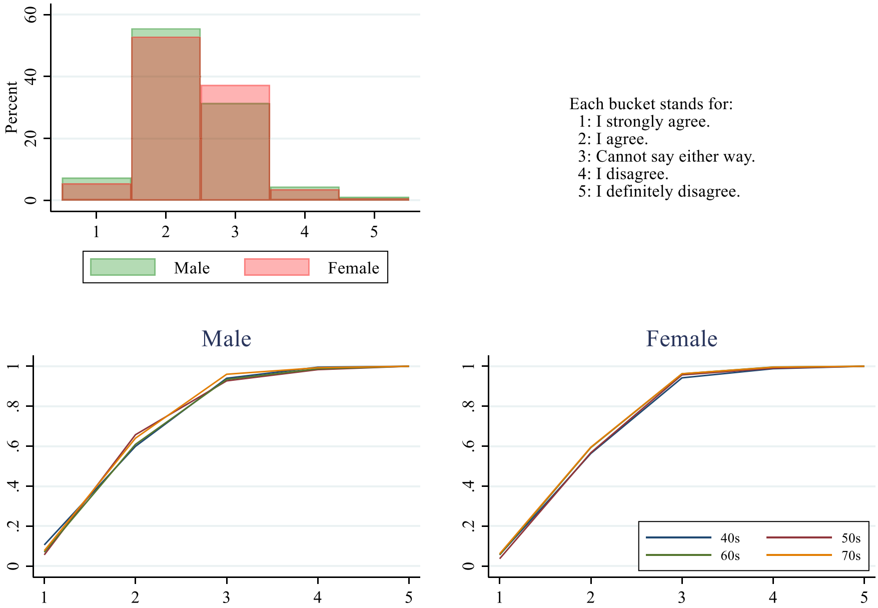


Fig. 44 Attitudes on future generations (Q42-2)

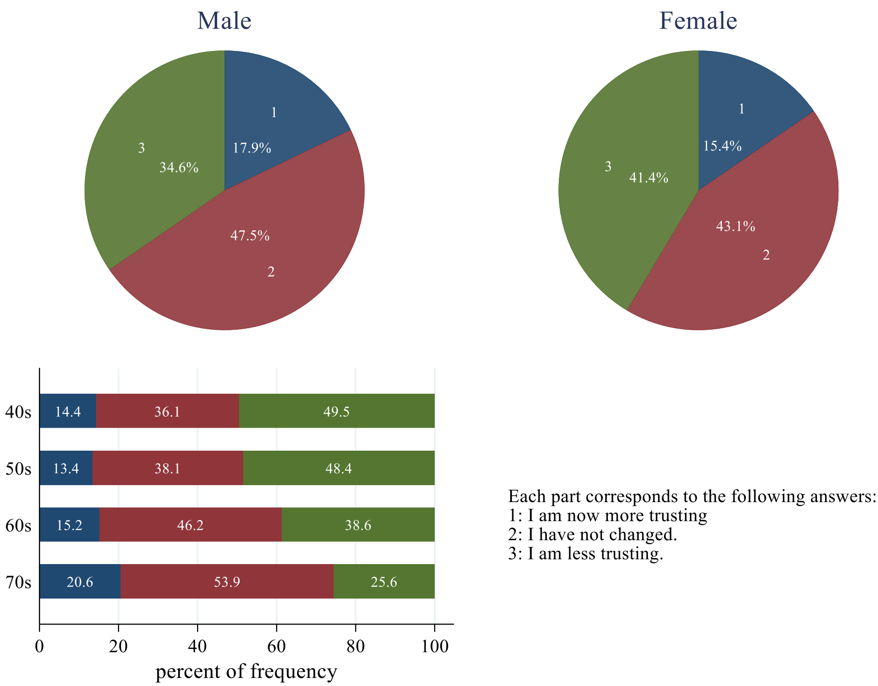


Fig. 45 Change in general trust (Q31)

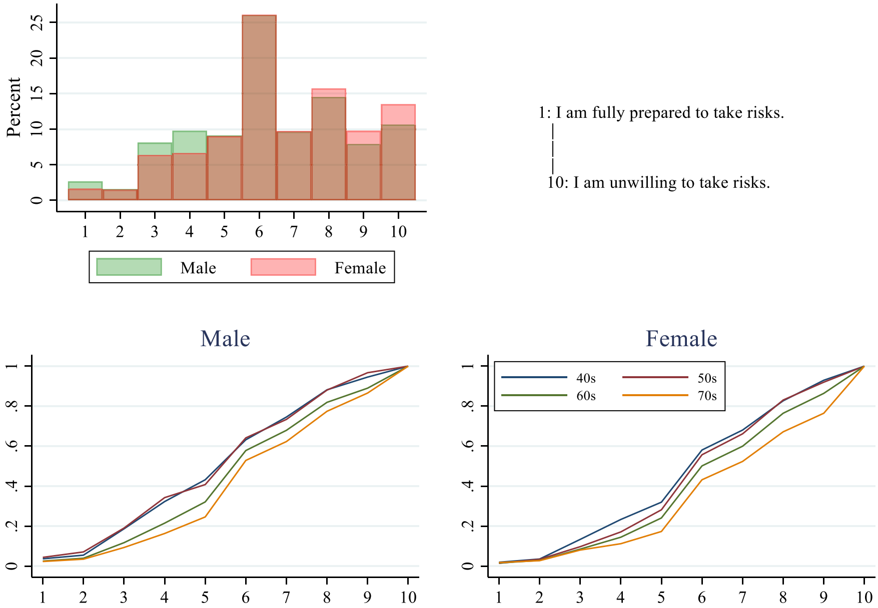


Fig. 46 Attitude toward risks (Q15)

would rather take the risky lottery. As Fig. 46 shows, people tend to be fairly risk averse; very few people think of themselves to be prepared to take a risk while many more people think of themselves as unwilling to take risks. At the same time, males are more willing to take risks than females. Moreover, older groups of people are less willing to take risks than younger, which is natural. As for the lottery of Q16, those who choose to take a chance of receiving 120,000 yen with probability 30% (which implies the expected value of 36,000 yen) over 60,000 yen are fairly risk loving. As Fig. 47 shows, men are much more inclined to take a chance than women. These findings from Q15 and Q16 are consistent, which suggests that the answers to Q15 accurately measure one's risk aversion.

2. **Health risk**: Attitudes toward regular healthcare may be an indicator of one's risk aversion. With this consideration, we ask several questions concerning a respondent's regular healthcare. Answers to health-related questions are expected to be affected by one's health. In order to control those effects, we measure a respondent's personal evaluations on his physical health[7] (Q5) and on his mental health; the latter is captured by the standard measure called K6[8] (Q27). The first question for measuring a risk aversion by means of health attitudes is if a respondent visits a dentist regularly (Q18). The alternatives for an

[7] This is often called self-rated or self-assessed health, which has been widely used to measure an individual's general health status and has been shown to be a powerful predictor of future morbidity and mortality. For example, see Mossey and Shapiro (1982) and Idler and Angel (1990).

[8] For details, see Kessler et al. (2002).

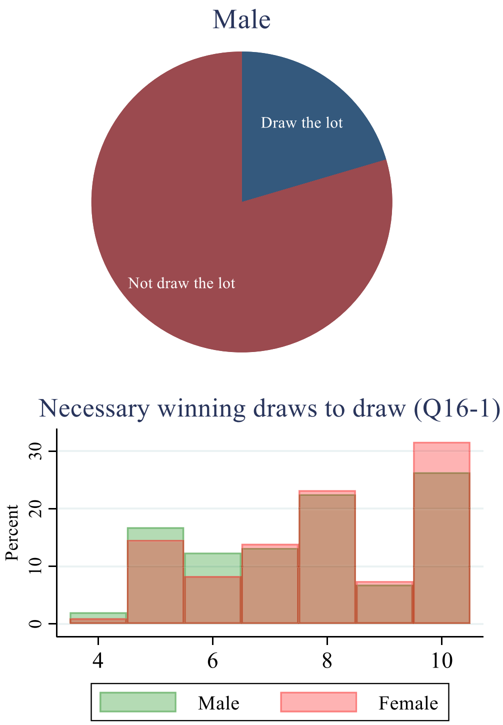


Fig. 47 Lottery drawing (Q16, Q16-1)

answer are: (1) he visits only when he has a problem with his teeth; (2) he visits regularly. Furthermore, we ask those who make regular visits how often they do (Q18-1). The alternatives for an answer are: (1) at least every three months; (2) once every half year; (3) once every year; (4) once every two years; (5) once or less every three years. We also ask at what age he started making regular dentist visit (Q18-2). The second question is if a respondent regularly takes a health examination or a complete medical checkup (Q19). The alternatives for an answer are: (1) yes; (2) no. Moreover, we ask at what age he started a regular health examination (Q19-1). The third question is if a respondent takes nutritional supplement (Q22). The alternatives for an answer are: (1) yes; (2) no. We also ask those who answer yes how much money he spends month (Q22-1). The alternatives for an answer are: (1) up to 1000 yen; (2) 1,01–3,000 yen; (3) 3001–5000 yen; (4) 5001–10,000 yen; (5) 10,000–20,000 yen; (6) more than 20,000 yen. Figures 48, 49, and 50 illustrate the distributions of answers to these questions. As Fig. 48 shows, a majority of people answer (to Q5) that they do not have health problems; younger people are in general healthier. As Fig. 49 shows, few people have mental problems; this does not differ across age groups. As Fig. 50 shows, about one third of people visit dentists regularly for check-ups. More women make regular visits, which is consistent with the above finding

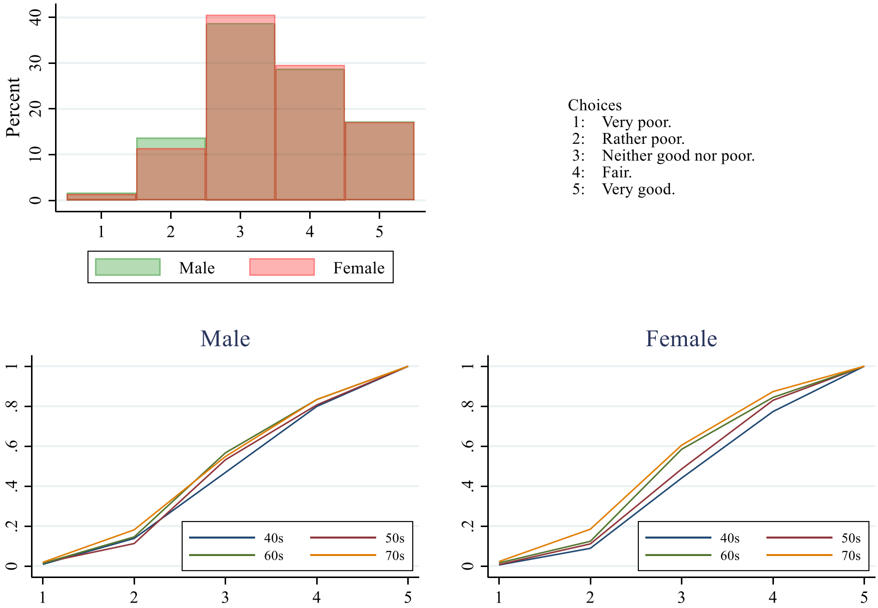


Fig. 48 Self-rated health (Q5)

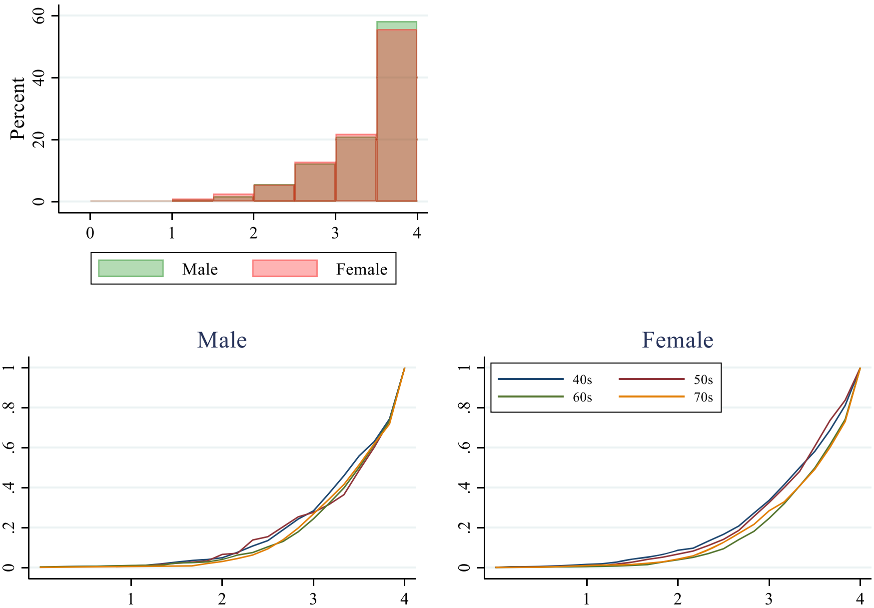


Fig. 49 K6 index (mental health) (Q27)

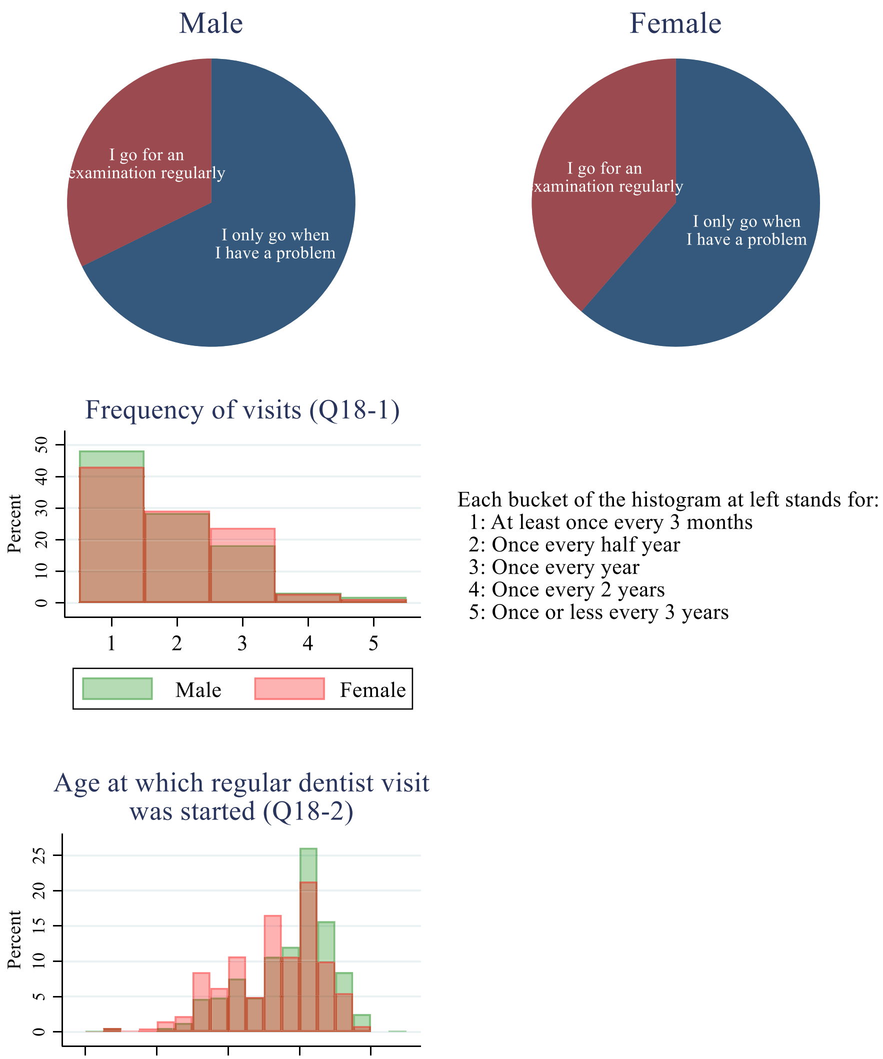


Fig. 50 Dentist visit (Q18)

that women are generally more risk averse (Q15). As the third and fourth panels show, males more often visit dentists and start taking dental care at a later stage of life than females; these may capture the fact that more males neglect daily care when they are young, which will cause problems when they become old. As Fig. 51 shows, interestingly, men and women are not so different with respect to regular medical check-ups; this may be because fewer women are employed than men, who are given regular medical check-ups at their workplaces under the law. As a result, the question on regular medical check-ups (Q19) may not be

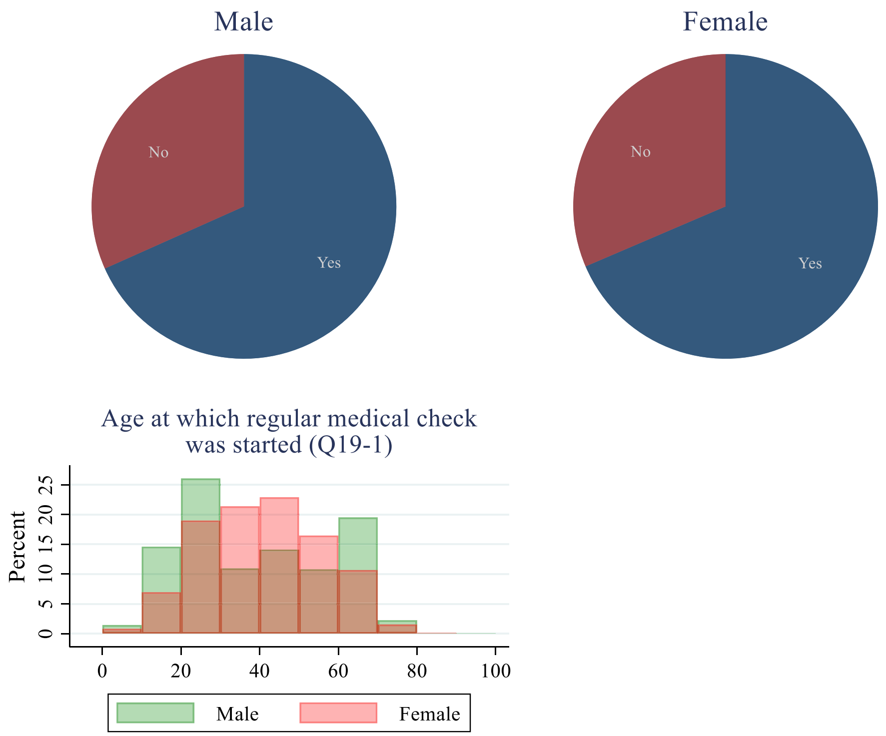


Fig. 51 Medical checkup (Q19)

as good a measure for risk aversion as that on regular dental check-ups (Q18). Another interesting finding on health risk aversion is that the use of nutritional supplements may serve as a measure for risk aversion. As Fig. 52 shows, more women take nutritional supplements than men, which is consistent with our finding that women are more risk averse (Q15). Moreover, the group of people above and in their 50 s take more nutritional supplements than the younger group. These findings suggest that the question on supplements may constitute a good measure for risk aversion once age and health are controlled.

3. **Financial risk**: With respect to financial risks, we ask if a respondent has purchased risky financial assets such as shares, bonds, and foreign currencies (Q26). The alternatives for an answer are: (1) yes, and he owns currently; (2) yes, but he does not own any now; (3) no; (4) I do not want to answer or know. Moreover, we ask those who answer yes at what age they started purchasing those risky assets (Q26-1). As Fig. 53 shows, more men are involved in financial asset than women. This suggests that women might be more risk averse in this respect as well. At the same time, in many households, husbands are main income earners, who might control financial decisions. If this factor can be controlled, the question on risk assets holding may provide a measure for risk aversion.

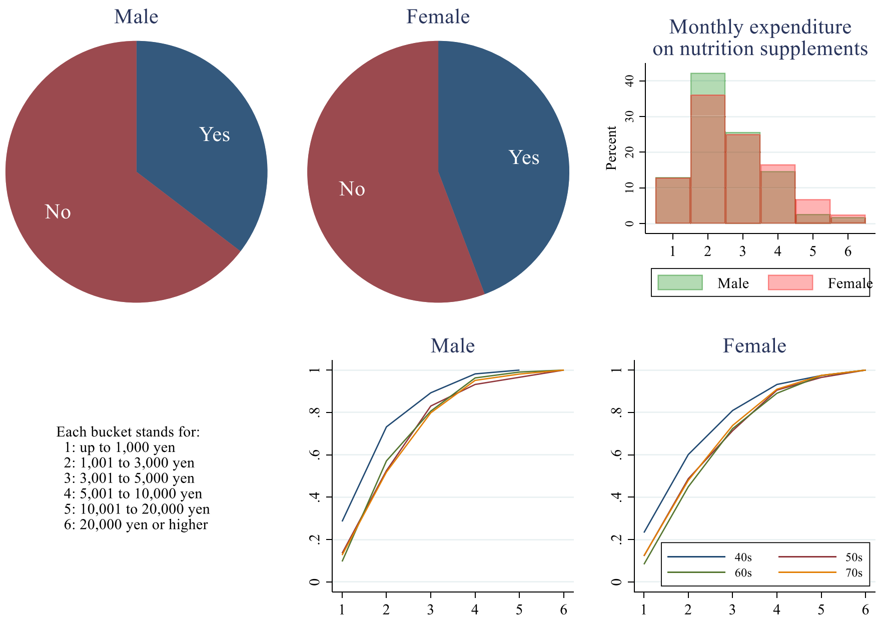


Fig. 52 Ingestion of nutritional supplements (Q22)

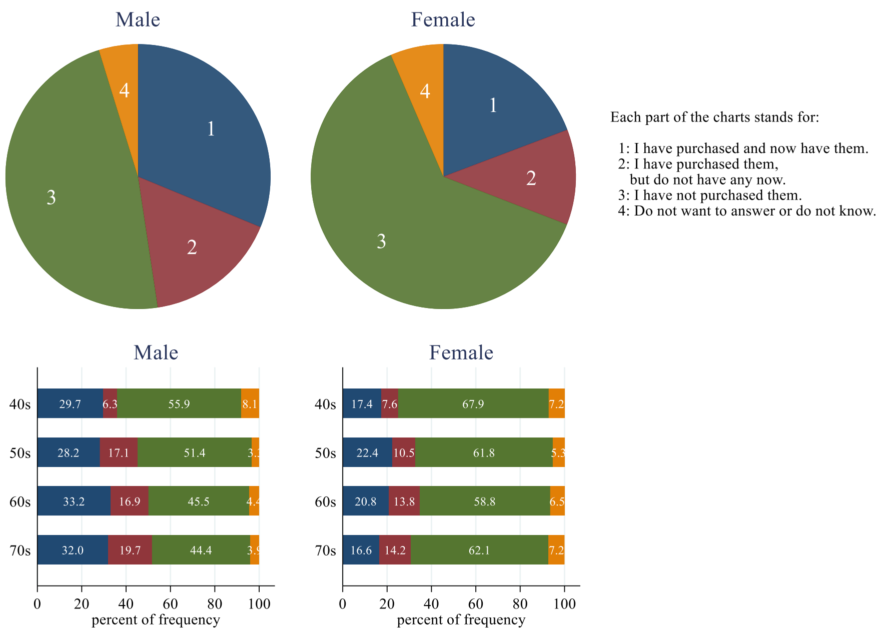


Fig. 53 Possession of risk assets (Q26)

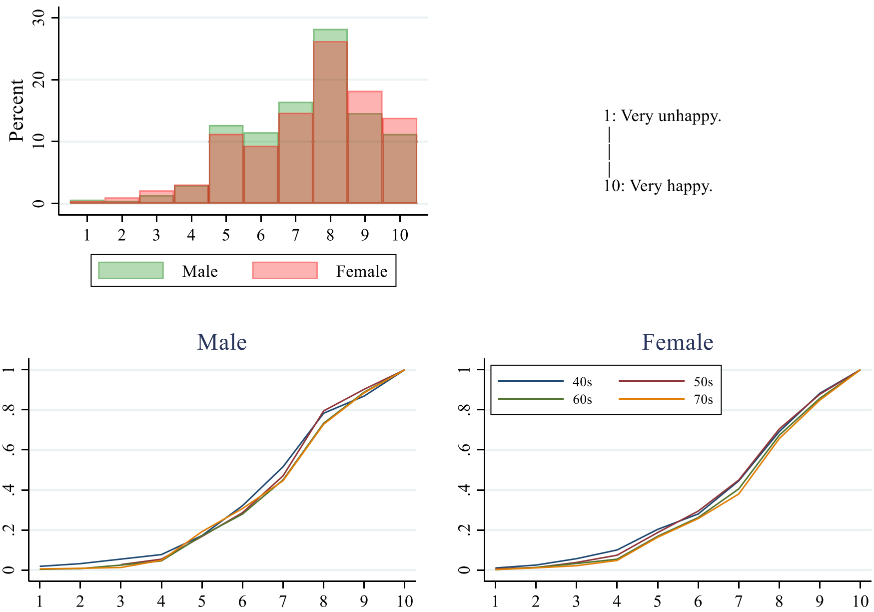


Fig. 54 Happiness (Q28)

3.4 Happiness

We ask about various personal perceptions on life, concerning happiness, fairness and views on medical systems. With respect to one's happiness, we ask how happy a respondent is (Q28) and how happy he thinks will be in five year (Q29). A respondent is asked to rate his happiness from 1 through 10. Figures 54 and 55 illustrate the distributions of answers to the questions on happiness. As Fig. 54 shows, more people are happy than not. Women tend to be happier than men. These findings do not vary much across age groups. As Fig. 55 shows, this does not change much between future and present happiness, although older people have less happy views on their future than younger people, which is natural.

3.5 Fairness and Medical System

We also ask about what sorts of things respondents find fair and unfair by presenting several situations (Q25):

Q25-1. A certain store has been selling snow shovels for 1800 yen. The morning after a large snowstorm, the store raises the price to 2400 yen.
Q25-2. A company has been making a fair profit. As a recession goes on, the unemployment rate has risen, which made it easier to replace workers if they quit.

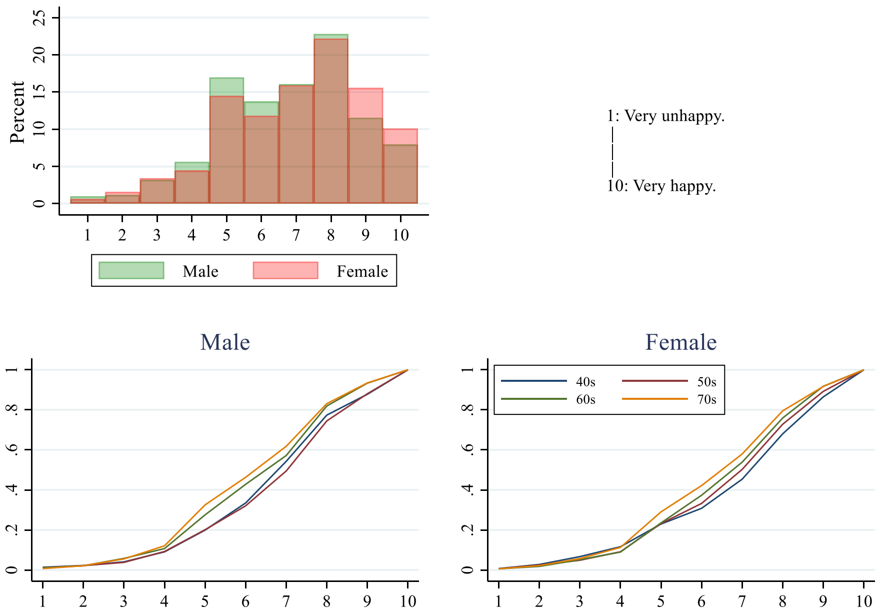


Fig. 55 Future happiness (Q29)

For this reason, the company decides to reduce salaries and wages by 10% for all its employees.
Q25-3. A small factory is making kitchen tables. Because of changes in the price of materials, the cost of making each table has decreased by 2400 yen. But the factory does not lower the price for the tables.
Q25-4. The only store in a small rural town began to sell a new chocolate product for 800 yen. But a store in a nearby town that is about one-hour drive away sells the same chocolate for 500 yen.

These questions reflect the concept of fairness in market activities developed as a part of Yano's market quality theory (Yano 2008, 2009). A respondent is asked to rate each of these statements. The alternatives for an answer are: (1) completely fair; (2) acceptable; (3) unfair; (4) very unfair. In Japan, the cost for national medical insurance is an important factor in fiscal debt. We ask about one's views on Japanese medical system. Towards this end, we first ask the monthly medical expense for a respondent (Q20). We then ask if a respondent is aware of the "High-Cost Medical Expense System", under which the government pays for a medical expense exceeding a set amount of payment (Q21). The alternatives for an answer are: (1) yes; (2) no. Moreover, we ask which of the following statements represents his view closest (Q23).

Q23-1. The level of medical care should be improved with the burden increased accordingly.

Q23-2. The level of medical care should be left unchanged with the burden remaining exactly at its present level.
Q23-3. The level of medical care should be reduced with the burden reduced in the future.

Finally, we ask about a respondent's view on the introduction of expensive new medical technologies by asking which of the following statements represents his view closest (Q24).

Q24-1. Medical insurance premiums should be increased to include high cost medical care, so that everyone can receive it.
Q24-2. It should be excluded from public medical care insurance so that people who want it can receive it at their own expense.

Figures 56, 57, 58, and 59 illustrate the distributions of answers to the questions on fairness. As they show, more people find the situations described in Q25-1 and Q25-2 to be more disturbing than those in Q25-3 and Q25-4. Q25-1 is concerned with windfall profits, whereas Q25-2 with opportunistic behaviour, leading to intentional wage cuts by firing existing workers. It is highly interesting that, except for Q25-2, older people have significantly stronger views on unfair practices than younger people; views do not vary across gender. It is an important research theme to investigate why this is the case; our survey teaches us little on this theme. Figures 60 and 61 illustrate the distributions of answers to Q23 and Q24. It is difficult to interpret answers to the questions on medical system (Q23). The first and second panels in Fig. 60 describe

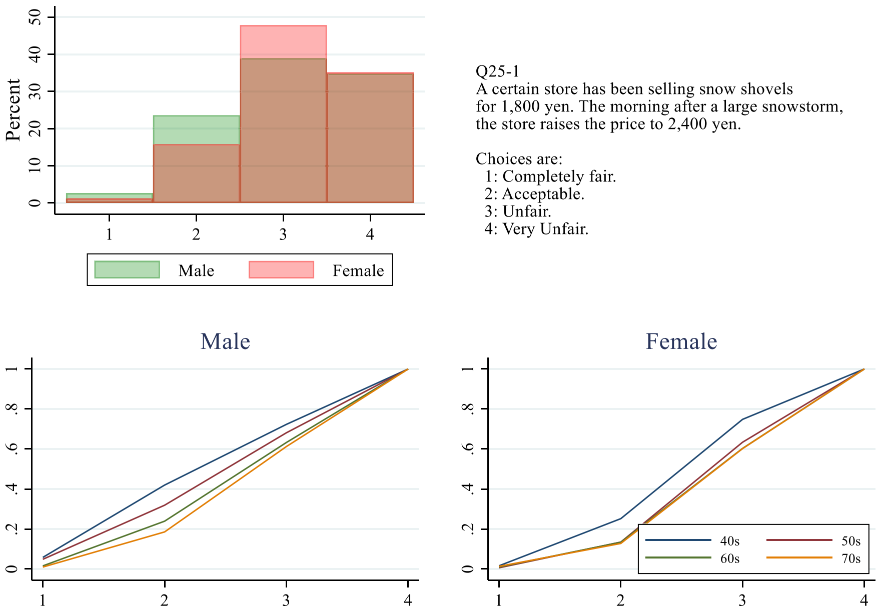
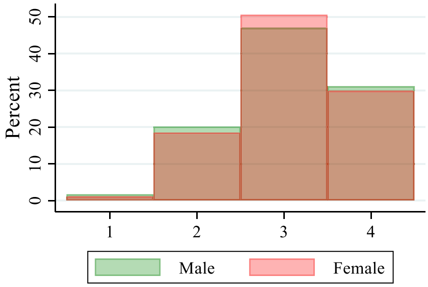


Fig. 56 Sense of fairness (Q25-1)



Q25-2
A company is making a small profit. However, due to a recession unemployment is high, so it is easy to hire people. The company, therefore, decides to reduce salaries and wages by 10% for all its employees.

Choices are:
1: Completely fair.
2: Acceptable.
3: Unfair.
4: Very Unfair.

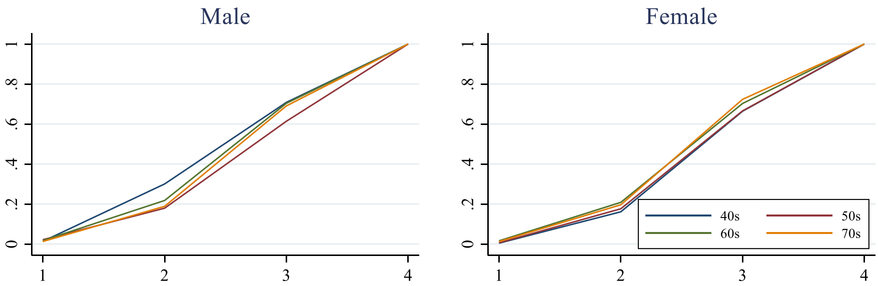
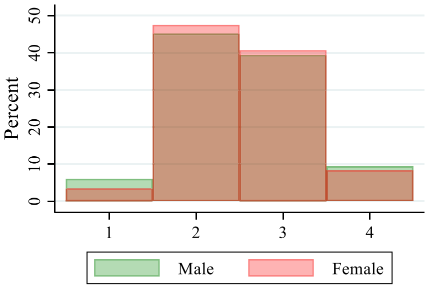


Fig. 57 Sense of fairness (Q25-2)



Q25-3
A small factory is making kitchen tables. Because of changes in the price of materials, the cost making each table has decreased by 2,400 yen. But the factory does not lower the price for the tables.

Choices are:
1: Completely fair.
2: Acceptable.
3: Unfair.
4: Very Unfair.

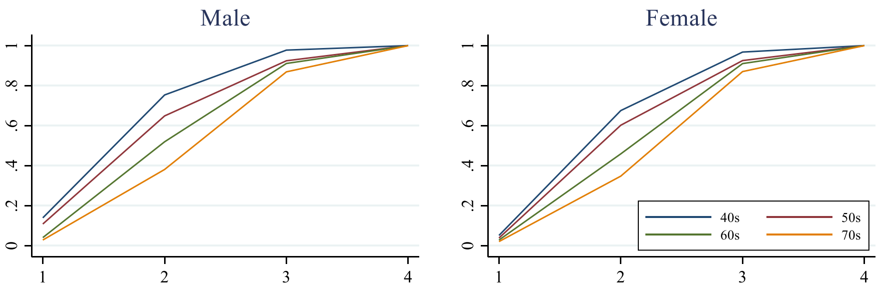
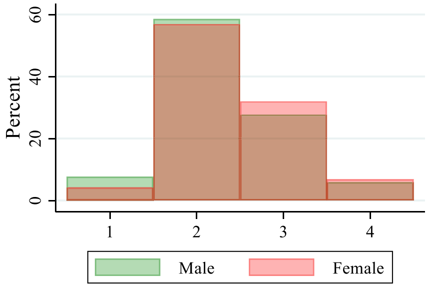


Fig. 58 Sense of fairness (Q25-3)



Q25-4
The only store in a small rural town began to sell a new chocolate product for 800 yen. But a store in a nearby town that is about 1 hour drive away sells the same chocolate for 500 yen.

Choices are:
1: Completely fair.
2: Acceptable.
3: Unfair.
4: Very Unfair.

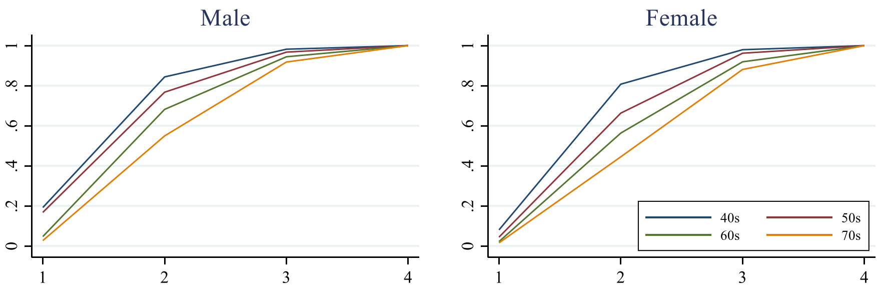
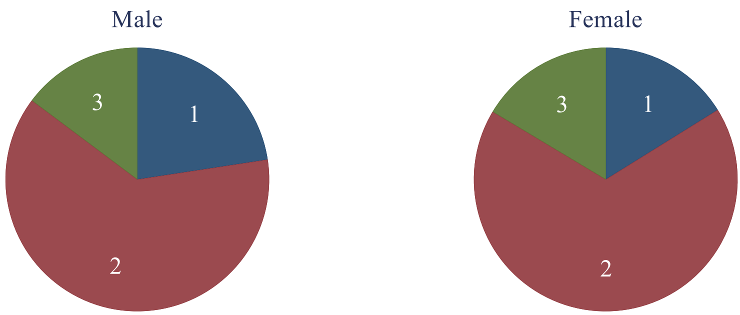
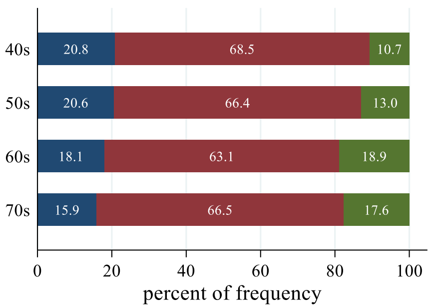


Fig. 59 Sense of fairness (Q25-4)





Each part corresponds to the following answers:
1: I want the level of medical care to be improved, if the burden is increased accordingly.
2: I want the level of medical care to be left unchanged, and the burden to remain at its present level.
3: I want the level of medical care to be reduced so as to lower the burden in the future.

Fig. 60 Attitude towards medical system (Q23)

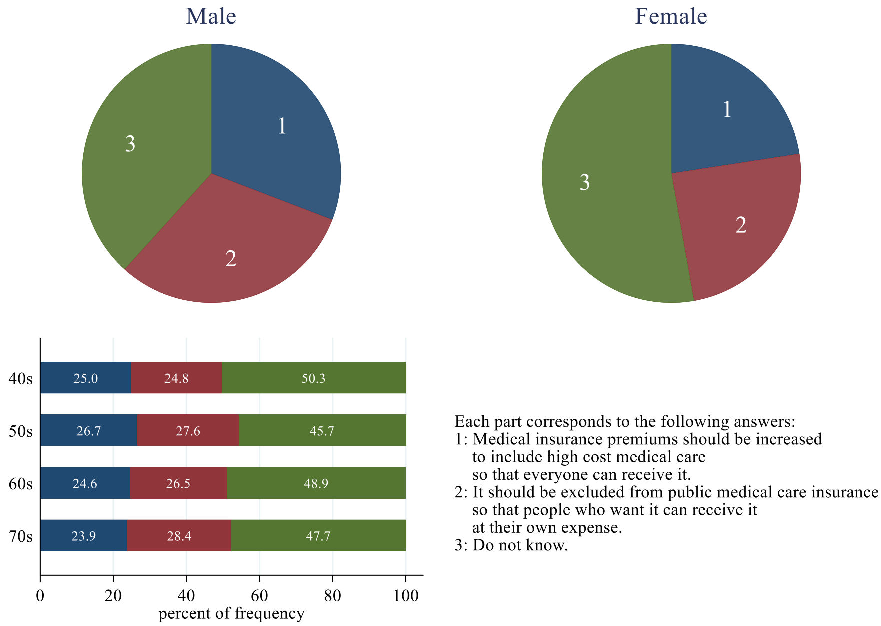


Fig. 61 Attitude towards very expensive medical technology (Q24)

that most males and females want to maintain the status quo of medical standards and burdens, but the percentage of males who want to raise both medical standards and burden is higher than that of females. The third panel shows that the older age group people are in, the less they want to raise both medical standards and burden. Question Q24 is concerned with so-called mixed medicine in Japan, strictly separating medical treatments on national health insurance and those on private expense; it is not permitted that a person pays part of treatments on particular illness on his own. As Fig. 61 shows, people's views are mixed.

Appendix: The Nagahama Survey

Questionnaire on Social and Economic Behavior

After answering, please send the questionnaire to the Zero-ji Health Promotion Club in the attached envelope. **Participation in this survey is optional**, but it is important to gain the cooperation of as many people as possible in order to conduct more accurate research, so please help us out. If the method of answering is not clear, please submit your inquiry to the Zero-ji Health Promotion Club.

I-We would like ask about you and your home.

1. Please tell us how many children now live with you.

	None	1	2	3	4	5 or more
Before elementary school	5,430	376	128	15	3	2
	(91.2%)	(6.3%)	(2.2%)	(0.3%)	(0.1%)	(0.0%)
Elementary and junior-high school students	4,735	579	510	122	6	2
	(79.5%)	(9.7%)	(8.6%)	(2.1%)	(0.1%)	(0.0%)
High school students	5,446	421	80	6	0	1
	(91.5%)	(7.1%)	(1.3%)	(0.1%)	(0.0%)	(0.0%)
University, graduate school, and vocational school students	5,653	245	53	3	0	0
	(94.9%)	(4.1%)	(0.9%)	(0.1%)	(0.0%)	(0.0%)
Employed	3,986	1,368	475	94	27	4
	(67.0%)	(23.0%)	(8.0%)	(1.6%)	(0.5%)	(0.1%)
Others (full-time home maker, unemployed)	5,367	433	115	31	2	6
	(90.1%)	(7.3%)	(1.9%)	(0.5%)	(0.0%)	(0.1%)

2. Do you live with your parents or your spouse's parents?

[1] Yes	[2] No
1,638	4,239
(27.5%)	(71.2%)

3. How many grandchildren do you have?

(　　)	Tens place	[⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨]
	Ones place	[⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨]

4. Do you live with any of your grandchildren?

[1] Yes	[2] No
996	4,953
(16.7%)	(83.2%)

5. How would you rate your general health status?

Very good	Fair	Neither good nor poor	Rather poor	Very poor
1,011	1,734	2,364	716	88
(17.0%)	(29.1%)	(39.7%)	(12.0%)	(1.5%)

6. Which of the following describes the last school you graduated from?

[1] Primary education institution (prewar elementary school)	Includes prewar ordinary primary schools and beginners course of national elementary schools.	5	(0.1%)
[2] Junior high school or other lower secondary education institution	Includes postwar middle schools, plus prewar higher elementary schools, advanced course of national elementary schools, youth schools, and elementary course in senior high schools.	1,059	(17.8%)
[3] High school or other upper secondary education institution	Includes postwar high schools, plus prewar secondary schools, teachers' college, preparatory courses, girls' high schools, technical colleges (technical college preparatory courses, and technical maintenance schools) etc.	2,625	(44.1%)

[4] University	Includes postwar universities and college level institutions, plus prewar universities, higher course in senior high schools, university preparatory courses, regular courses in teachers' colleges, higher normal schools, women's higher normal schools, vocational schools etc.	684	(11.5%)
[5] Graduate school		27	(0.5%)
[6] Two-year college		748	(12.6%)
[7] Technical college		422	(7.1%)
[8] Higher technical college		60	(1.0%)
[9] Do not want to answer.		43	(0.7%)

6-1. [Answer if you answered [4] University or [5] Graduate school above.] Which of the following did you specialize in?

Literature	Education	Law	Economics	Science
101	133	49	125	22
(1.7%)	(2.2%)	(0.8%)	(2.1%)	(0.4%)
Medicine or dentistry	Pharmacolog y	Engineering	Agriculture	Others
6	10	120	19	122
(0.1%)	(0.2%)	(2.0%)	(0.3%)	(2.1%)

7. Please report the year you completed your last education.

[1] Showa (1925 - 1988); [2] Heisei (1989 – present)		
( ) year	Tens place	[⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨]
	Ones place	[⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨]

8. Tell us about your present work. Which of the following describes your form of employment?

[1] Am not employed (full-time housemaker, student, retiree, etc.)	2,608	(43.8%)
[2] Employee (person employed by or working for a company, organization etc. (person who is formally employed by an employer))	2,052	(34.5%)
[3] Self-employed (restaurant, wholesale/retail shop owner, farming etc.)	515	(8.7%)
[4] Independent professional (physician, lawyer, accountant, tax accountant, author, etc.)	49	(0.8%)
[5] Family worker (restaurant, retail store, farming etc.)	192	(3.2%)
[6] Works at home without an employment relationship with a company	88	(1.5%)
[7] Contract worker, sub-contractor (person with no employment relationship)	116	(2.0%)
[8] Do not want to answer.	41	(0.7%)

8-1. [Answer if you selected [2] Employed person above.] Which of the following describes your position in your company?

[1] Full-time employee (regular employee) -- below manager level	469	(7.9%)
[2] Full-time staff member or employee (regular employee) -- manager level	256	(4.3%)
[3] Full-time employee (regular employee) -- executive level	41	(0.7%)
[4] Contract employee	140	(2.4%)
[5] Temporary or part-timer	1,026	(17.2%)
[6] Dispatched worker	44	(0.7%)
[7] Commissioned	61	(1.0%)
[8] Do not want to answer.	5	(0.1%)

9. Which of the following describes the work that you usually perform?

[1] Agricultural, forestry, and fishery work	290	(4.9%)
[2] Mining work	1	(0.0%)
[3] Sales work (manager, inside employee, outside employee of retailer or wholesaler, real-estate agent, etc.)	329	(5.5%)
[4] Service work (barber, hair-dresser, restaurant, hotel worker and janitor, etc.)	380	(6.4%)
[5] Administrative and managerial work (elected member of national or regional government, section chief or higher in a company, organization, or public agency)	99	(1.7%)
[6] Clerical work (ordinary clerical work, accounting work, operator or other clerical worker etc.)	483	(8.1%)
[7] Transportations and communications work (driver, conductor on a train, bus, ship, or aircraft, telegraph or radio operator etc.)	58	(1.0%)
[8] Manufacturing, construction, maintenance, or movers and delivery work	426	(7.2%)
[9] Data processing technologist (System engineer, programmer, etc.)	6	(0.1%)
[10] Specialized or technical work (Excluding data processing technologist (corporate researchers, engineers, medical doctors and health care service providers, lawyers and legal staff, teachers, artists, etc.)	428	(7.2%)
[11] Security work (Self-defense force member, police officer, fire-fighter, security guard, etc.)	6	(0.1%)
[12] Others	655	(11.0%)
[13] Do not want to answer.	38	(0.6%)

10. What are the average number of hours that you work for wages a week? Please answer including overtime hours. If you work at 2 or more wage-earning jobs, please answer indicating the total number of hours you work.

About ( ) hours	Tens place	[⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨]
	Ones place	[⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨]

II- We would like to ask about your income, assets, etc.

Please answer on your household as a whole.

11. Which of the following corresponds to <u>your household's</u> annual income before you pay taxes and social insurance premiums.? Please include all the side-job income and various benefits.

① No more than 2 million yen	② Greater than 2 million and no more than 4 million yen.	③ Greater than 4 million and no more than 6 million yen.	④ Greater than 6 million and no more than 8 million yen.
680	1,739	930	523
(11.4%)	(29.2%)	(15.6%)	(8.8%)
⑤ Greater than 8 million and no more than 10 million yen.	⑥ Greater than 10 million and no more than 15 million yen.	⑦ Greater than 15 million yen.	⑧ I do not know. / I do not want to answer.
350	229	58	1,128
(5.9%)	(3.9%)	(1.0%)	(19.0%)

12. Which of the following corresponds to <u>your household's</u> total present bank deposits, shares, and investment trusts?

① No more than 2 million yen	② Greater than 2 million and no more than 4 million yen.	③ Greater than 4 million and no more than 6 million yen.	④ Greater than 6 million and no more than 8 million yen.	⑤ Greater than 8 million and no more than 10 million yen.
727	462	393	250	361
(12.2%)	(7.8%)	(6.6%)	(4.2%)	(6.1%)
⑥ Greater than 10 million and no more than 15 million yen.	⑦ Greater than 15 million yen.	⑧ Greater than 20 million yen.	⑨ I do not know. / I do not want to answer.	
378	295	791	2,002	
(6.4%)	(5.0%)	(13.3%)	(33.6%)	

Please answer on yourself.

13. Which of the following corresponds to your personal annual income before you pay taxes and social insurance premiums.? Please include all the side-job income and various benefits.

① No more than 2 million yen	② Greater than 2 million and no more than 4 million yen.	③ Greater than 4 million and no more than 6 million yen.	④ Greater than 6 million and no more than 8 million yen.
3,043	1,376	329	155
(51.1%)	(23.1%)	(5.5%)	(2.6%)
⑤ Greater than 8 million and no more than 10 million yen.	⑥ Greater than 10 million and no more than 15 million yen.	⑦ Greater than 15 million yen.	⑧ I do not know. / I do not want to answer.
63	29	5	709
(1.1%)	(0.5%)	(0.1%)	(11.9%)

14. Which of the following corresponds to the present total bank deposits, shares, and investment trusts in your own name?

① No more than 2 million yen	② Greater than 2 million and no more than 4 million yen.	③ Greater than 4 million and no more than 6 million yen.	④ Greater than 6 million and no more than 8 million yen.	⑤ Greater than 8 million and no more than 10 million yen.
1,527	674	407	238	348
(25.7%)	(11.3%)	(6.8%)	(4.0%)	(5.8%)
⑥ Greater than 10 million and no more than 15 million yen.	⑦ Greater than 15 million yen.	⑧ Greater than 20 million yen.	⑨ I do not know. / I do not want to answer.	
332	176	377	1,624	
(5.6%)	(3.0%)	(6.3%)	(27.3%)	

III-We would like to ask about your inclinations and attitudes concerning your behavior.

Anything that may result in some form of loss in the future is called “risk”. For example, if you take a trip outside the country, you might have an accident if you are unlucky. If you clearly decide to set out on such a trip aware that such an incident may occur, you are taking such a risk. If you do not set out on a trip, you are not taking any risk at all.

15. Do you think that you are the type of person who is fully prepared to take risks concerning all matters? Or do you try to avoid taking risks? Please indicate the level between ① “I am unwilling to take risks” and ⑩ “fully prepared to take risks” that most closely indicates your type by covering the number in black.

I am unwilling to take risks ←-- →I am fully prepared to take risks									
①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
705	513	859	543	1,460	506	428	388	85	110
(11.8%)	(8.6%)	(14.4%)	(9.1%)	(24.5%)	(8.5%)	(7.2%)	(6.5%)	(1.4%)	(1.9%)

16. You have a choice between receiving 60,000 yen for sure and drawing a lottery that will give you 120,000 yen if you win, but not a penny if you lose. The lottery contains three "winners" out of ten. Would you draw the lottery, or would you not draw the lottery and receive 60,000 yen?

[1] Draw a lot	772	(13.0%)
[2] Not draw a lot	4,904	(82.4%)

16-1. [Answer if you answered “[2] Not draw a lot” above.] Of the 10 lots, what is the minimum number of winning draws per 10 draws would there have to be for you to draw a lot?

④ 4	⑤ 5	⑥ 6	⑦ 7	⑧ 8	⑨ 9	⑩ 10
59	713	445	641	1,077	339	1,407
(1.0%)	(12.0%)	(7.5%)	(10.8%)	(18.1%)	(5.7%)	(23.6%)

17. Which do you choose, "Receive 60,000 yen today" or "Wait for one week and receive 60,050 yen"?

[1] Receive 60,000 yen today.	3,727	(62.6%)
[2] "Wait for one week and receive 60,050 yen"	1,425	(23.9%)

17-1. [Answer if you answered, "[1] Receive 60,000 yen today"] What is the least you would have added to the 60,000 yen to make you wait one week? Answer to the nearest unit of 10 yen.

( ) yen	
10 Thousands place	[⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨]
Thousands place	[⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨]
Hundreds place	[⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨]
Tens place	[⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨]

18. Do you visit a dentist regularly?

[1] I only go when I have a problem with my teeth.	3,582	(60.2%)
[2] I go for an examination regularly.	2,069	(34.8%)

18-1. [Answer if you answered, "(2) I go regularly" above"] How often do you go?

① At least once every 3 months	② Once every half year	③ Once every year	④ Once every 2 years	⑤ Once or less every 3 years
925	603	463	61	29
(15.5%)	(10.1%)	(7.8%)	(1.0%)	(0.5%)

18-2. [Answer if you answered, "I go regularly" above"] How old were you when you began to go regularly?

From about ( )	
Tens place	[⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨]
Ones place	[⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨]

19. Do you regularly have a health examination or take a thorough medical checkup ? Exclude a check up by our Nagahama Survey

[1] Yes	3,930	(66.0%)
[2] No	1,809	(30.4%)

19-1. [Answer if you answered, "[1] Yes" above] About how old were you when you began to receive health examinations regularly?

From about ( )												
Tens place	[	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	]
Ones place	[	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	]

20. How much do you pay as medical expense every month (fees paid at your expense to medical treatment organizations and pharmacies)? Exclude visits because of injuries. If you visit more than one hospital, please answer by reporting the total amount.

About ( ) thousands yen	100 Thousands place	[	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	]
	10 Thousands place	[	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	]
	Thousands place	[	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	]

21. Have you heard of the high medical expense system (the system in which the government pays the part of medical payments at hospitals and pharmacies that exceed a certain amount)?

[1] Yes	[2] No
5,202	590
(87.4%)	(9.9%)

22. Do you normally take nutritional supplements?

[1] Yes	[2] No
2,395	3,385
(40.2%)	(56.9%)

22-1. [Answer if you answered "[1] Yes" above.] About how much money do you pay for nutritional supplements every month?

① up to 1,000 yen	② 1,001 to 3,000 yen	③ 3,001 to 5,000 yen	④ 5,001 to 10,000 yen	⑤ 10,000 to 20,000 yen	⑥ 20,000 yen or higher
306	896	598	382	136	55

(5.1%)	(15.1%)	(10.0%)	(6.4%)	(2.3%)	(0.9%)

23. Which of the following policies concerning medical care fees most closely resembles your thoughts?

① I want the level of medical care to be improved, even if the burden is increased accordingly.	1,028	(17.3%)
② I want the level of medical care to be left unchanged, and the burden to remain at its present level.	3,718	(62.5%)
③ I want the level of medical care to be reduced so as to lower the burden.	896	(15.1%)

24. Expensive medical care technology, like some new medicines that cost tens of millions of yen a year, is being developed. Which statement concerning such high cost medical care most closely represents your thoughts on this topic?

① Medical insurance premiums should be increased to include high cost medical care so that everyone can receive it.	1,442	(24.2%)
② It should be excluded from public medical care insurance so that people who want it can receive it at their own expense.	1,523	(25.6%)
③ Don't know.	2,756	(46.3%)

25. Do you think the cases described on the following table are fair?

	Completely fair	Acceptable	Unfair	Very unfair
(1) A certain store has been selling snow shovels for 1,800 yen. The morning after a large snowstorm, the store raises the price to 2,400 yen.	96	1,054	2,593	2,019
	(1.6%)	(17.7%)	(43.6%)	(33.9%)
(2) A company is making a small profit. However, due to a recession unemployment is high, so it is easy to hire people. The company, therefore, decides to reduce salaries and wages by 10% for all its	73	1,076	2,794	1,709
	(1.2%)	(18.1%)	(46.9%)	(28.7%)

employees.				
(3) A small factory is making kitchen tables. Because of changes in the price of materials, the cost making each table has decreased by 2,400 yen. But the factory does not lower the price for the tables.	242 (4.1%)	2,655 (44.6%)	2,286 (38.4%)	494 (8.3%)
(4) The only store in a small rural town began to sell a new chocolate product for 800 yen. But a store in a nearby town that is about 1 hour drive away sells the same chocolate for 500 yen.	304 (5.1%)	3,282 (55.1%)	1,749 (29.4%)	374 (6.3%)

26. Have you purchased risky financial assets such as shares, bonds, or foreign-currency denominated assets etc. in addition to your bank deposits? Do you now have such assets?

[1] I have purchased and now have them.	1,325	(22.3%)
[2] I have purchased them, but do not have any now.	756	(12.7%)
[3] I have not purchased them.	3,326	(55.9%)
[4] Do not want to answer or do not know.	341	(5.7%)

26-1. [Answer if you answered “[1] I have purchased and now have them.”, or “[2] I have purchased them, but do not have any now.”’] How old were you when your first purchased risky financial assets such as shares, bonds, or foreign-currency denominated assets etc.?

( ) years of age	
Tens place	[⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨]
Ones place	[⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨]

27. During the last 30 days, about how often did you feel ...

	Never	Few times	Sometimes	Usually	Always
(5) … nervous?	2,614 (43.9%)	1,642 (27.6%)	1,101 (18.5%)	204 (3.4%)	111 (1.9%)

(6) … hopeless?	3,836	1,197	507	86	45
	(64.4%)	(20.1%)	(8.5%)	(1.4%)	(0.8%)
(7) …restress or fidgety?	2,900	1,896	747	93	37
	(48.7%)	(31.8%)	(12.6%)	(1.6%)	(0.6%)
(8) ... so depressed that nothing could cheer you up?	2,799	1,937	724	149	66
	(47.0%)	(32.5%)	(12.2%)	(2.5%)	(1.1%)
… that everything was an effort?	2,899	1,942	661	133	46
	(48.7%)	(32.6%)	(11.1%)	(2.2%)	(0.8%)
… worthless?	3,769	1,253	493	101	72
	(63.3%)	(21.0%)	(8.3%)	(1.7%)	(1.2%)

28. How happy are you now? "Please indicate the number between ① "very unhappy/" and ⑩ "very happy" that most closely describes you by covering the number in black.

very unhappy←--→very happy									
①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
28	47	109	177	679	582	883	1,559	991	756
(0.5%)	(0.8%)	(1.8%)	(3.0%)	(11.4%)	(9.8%)	(14.8%)	(26.2%)	(16.6%)	(12.7%)

29. How happy do you think you will be five years from now? "Please indicate the number between ① "very unhappy/" and ⑩ "very happy" that most closely describes your opinion by covering the number in black.

very unhappy←--→very happy									
①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
42	82	192	276	875	711	915	1,283	818	540
(0.7%)	(1.4%)	(3.2%)	(4.6%)	(14.7%)	(11.9%)	(15.4%)	(21.6%)	(13.7%)	(9.1%)

IV- We would like to ask about your relationships with the region in which you live.

30. Generally speaking, would you say that most people can be trusted? Or that you need to be very careful in dealing with people? "Please indicate the number between ① "Most people can be trusted." and ⑩ "You need to be very careful in dealing with people" that most closely describes your opinion by covering the number in black.

Most people can be trusted←				-------------------------------- →	You need to be very careful in dealing with people				
①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
271	739	1,143	632	1,334	528	525	391	118	104
(4.6%)	(12.4%)	(19.2%)	(10.6%)	(22.4%)	(8.9%)	(8.8%)	(6.6%)	(2.0%)	(1.8%)

31. How has the consciousness that motivated you to answer Question 30 above changed from the time you were 15 years old?

[1] I am now more trusting	[2] I have not changed.	[3] I am less trusting.	[4] Don't know.
750	2,062	1,814	1,134
(12.6%)	(34.6%)	(30.5%)	(19.1%)

32. Do you think that most people "would try to take advantage of you (your weaknesses) if they got the chance."? Or do you think that "they would try to be fair"? Please indicate the number between ① "would try to be fair" and ⑩ "would try take advantage of you (your weaknesses)" that most closely describes your opinion by covering the number in black.

would try to take advantage of you ←				-- →			they would try to be fair		
①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
146	204	296	376	1,189	702	672	1,010	618	313
(2.5%)	(3.4%)	(5.0%)	(6.3%)	(20.0%)	(11.8%)	(11.3%)	(17.0%)	(10.4%)	(5.3%)

33. To what degree do you interact with your neighbors?

① I have someone with whom I cooperate in my daily life, for example, by giving each other advice or loaning each other daily necessities.	1,313	(22.1%)
② I associate with some neighbors by regularly chatting with them.	3,053	(51.3%)
③ I only associate with them at the minimum level of exchanging greetings.	1,367	(23.0%)
④ I do not associate with them at all.	47	(0.8%)

34. How many people do you interact with on friendly terms?

① I am acquainted with or interact with many of my neighbors (generally 20 people or more).	1,501	(25.2%)
② I am acquainted with or interact with some of my neighbors (generally from 5 to 19 people).	3,045	(51.1%)
③ I am acquainted with or interact with very few of my neighbors (4 people or fewer).	1,205	(20.2%)
④ I do not even know who lives next door.	42	(0.7%)

35. To what degree do you think you can count on neighbors, relatives, and workmates to seek for help to deal with daily problems and concerns?

	Can trust them very much	Can trust them somewhat	Cannot say either way	Cannot trust very much	Cannot trust at all
Neighbors	456	2,576	1,547	876	310
	(7.7%)	(43.3%)	(26.0%)	(14.7%)	(5.2%)
Family members	3,941	1,519	188	92	23
	(66.2%)	(25.5%)	(3.2%)	(1.6%)	(0.4%)
Relatives	1,290	3,080	894	383	131
	(21.7%)	(51.7%)	(15.0%)	(6.4%)	(2.2%)
Friends and acquaintances	700	2,911	1,564	462	125
	(11.8%)	(48.9%)	(26.3%)	(7.8%)	(2.1%)
Workmates	241	1,278	1,552	659	433
	(4.1%)	(21.5%)	(26.1%)	(11.1%)	(7.3%)

36. During the past year, have you donated money to a non-profit organization or an organization conducting charitable activities?

[1] I have not	[2] 1 to 999 yen	[3] 1,000 yen to 4,999 yen	[4] 5,000 yen to 9,999 yen	[5] 10,000 to 49,999 yen	[6] 50,000 yen or higher
1,650	1,074	2,075	432	369	124
(27.7%)	(18.0%)	(34.9%)	(7.3%)	(6.2%)	(2.1%)

37. How often do you usually interact with friends, relatives, and workmates?

	Daily (from daily to weekly)	A certain number of times (once a week to a few times a month)	Rarely (few times in several years)	Never
Friends and acquaintances (excluding classmates or workmates)	694	2,833	1,858	212
	(11.7%)	(47.6%)	(31.2%)	(3.6%)
Relatives	693	2,901	1,933	129
	(11.6%)	(48.7%)	(32.5%)	(2.2%)
Workmates	562	967	1,524	1,022
	(9.4%)	(16.2%)	(25.6%)	(17.2%)

38. Do you participate in the following activities? If you do participate, how often do you participate?

	Almost every week	About 2 or 3 days per month	About 1 day per month	A few times a year	I am not active.
Local community activities	327	715	1,090	2,618	912
[Residents association, town association, women's association, seniors club, youth association, children's groups]	(5.5%)	(12.0%)	(18.3%)	(44.0%)	(15.3%)
Sports, hobbies, recreational activities	1,271	1,027	531	806	2,006
[Various sports, artistic and cultural activities, lifetime learning, etc.]	(21.4%)	(17.3%)	(8.9%)	(13.5%)	(33.7%)
Volunteer, NPO, civic activities	199	375	536	1,607	2,892
[Community improvement, beautification, disaster and crime prevention, environment, international aid, etc.]	(3.3%)	(6.3%)	(9.0%)	(27.0%)	(48.6%)
Activities of other organizations	188	220	404	1,012	3,621
[Chamber of commerce, professional associations, religion, political etc.]	(3.2%)	(3.7%)	(6.8%)	(17.0%)	(60.8%)

39. Do you want your children's or grandchildren's generations to continue to live in the region where you now live?

① I do	② I do not	③ I don't know.
2,942	830	1,553
(49.4%)	(13.9%)	(26.1%)

40. Do you want to contribute to fixing community problems such as the decline of a local shopping street, an increase in abandoned land and houses, and local child-care activities?

①Yes, absolutely.	② Yes, if possible.	③ No, not very much.	④ Absolutely not.	⑤ I don't know.
180	1,952	1,590	83	1,763
(3.0%)	(32.8%)	(26.7%)	(1.4%)	(29.6%)

41. How much do you personally trust each of the following institutions?

	I strongly trust them	I somewhat trust them	Cannot say either way.	I do not trust them very much	I do not trust them at all	Don't know.
National Diet	43	1,161	1,484	1,689	616	614
	(0.7%)	(19.5%)	(24.9%)	(28.4%)	(10.4%)	(10.3%)
Government	67	1,267	1,395	1,593	677	592
	(1.1%)	(21.3%)	(23.4%)	(26.8%)	(11.4%)	(9.9%)
Local governments	117	2,260	1,688	885	211	425
	(2.0%)	(38.0%)	(28.4%)	(14.9%)	(3.5%)	(7.1%)
Courts	347	2,014	1,517	427	145	1,098
	(5.8%)	(33.8%)	(25.5%)	(7.2%)	(2.4%)	(18.4%)
Police	428	3,015	1,114	505	128	403
	(7.2%)	(50.6%)	(18.7%)	(8.5%)	(2.2%)	(6.8%)
Banks, securities dealers and other financial institutions	327	2,740	1,449	493	97	493
	(5.5%)	(46.0%)	(24.3%)	(8.3%)	(1.6%)	(8.3%)

42. Do you agree with the following ideas?

	Strongly agree	Agree	Cannot say either way	Disagree	Definitely disagree	Do not know.
If I help others, someone will help me when I am in difficulty.	537	2,564	2,090	196	56	230
	(9.0%)	(43.1%)	(35.1%)	(3.3%)	(0.9%)	(3.9%)
In order to let our future generations, including children and grandchildren, have the same standard of living and level of public services as we now receive, an increase of some degree in the burden we now bear is acceptable.	331	2,907	1,918	210	44	258
	(5.6%)	(48.8%)	(32.2%)	(3.5%)	(0.7%)	(4.3%)

This concludes this questionnaire. Thank you very much for your cooperation.

References

Hirota S, Seto K, Yodo M, Yano M (2021) Socio-Life Scientific Survey on COVID-19. In Yano M et al. (eds.), Socio-life Science and the COVID-19 Outbreak: Public Health and Public Policy, Springer.

Idler EL, Angel RJ (1990) Self-rated health and mortality in the NHANES-I Epidemiologic Follow-up Study. Am J Public Health 80(4):446–452. https://doi.org/10.2105/AJPH.80.4.446

Inaba Y (2014) Has Japan's Social-Relational Capital Been Damaged?: Changes in Social Relationship Capital from the 2001 National Survey and the 2013 National Survey (in Japanese). Seikei Kenkyu 51(1):1–30

Inglehart R, Haerpfer C, Moreno A, Welzel C, Kizilova K, Diez-Medrano J, Lagos M, Norris P, Ponarin E (eds.) BPea (2014) World Values Survey: All Rounds—Country-Pooled Datafile.

Kessler RC, Andrews G, Colpe LJ, Hiripi E, Mroczek DK, Normand SL, Walters EE, Zaslavsky AM (2002) Short screening scales to monitor population prevalences and trends in non-specific psychological distress. Psychol Med 32(6):959–976

Meiji-Yasuda Life Insurance Company (2019) Questionnaire Survey on Health (in Japanese), https://www.meijiyasuda.co.jp/profile/news/release/2019/pdf/20190905_01.pdf

Mossey JM, Shapiro E (1982) Self-rated health: a predictor of mortality among the elderly. Am J Public Health 72(8):800–808. https://doi.org/10.2105/AJPH.72.8.800

Scrivens K, Smith C (2013) Four Interpretations of Social Capital: An Agenda for Measurement. OECD Publishing; 2013. DOI https://doi.org/10.1787/5jzbcx010wmt-en

Setoh K, Matsuda F (2021) Cohort profile: The Nagahama Prospective Genome Cohort for Comprehensive Human Bioscience (The Nagahama Study). In Yano M et al. (eds.), Socio-life Science and the COVID-19 Outbreak: Public Health and Public Policy, Springer.

Yano M (2008) Competitive fairness and the concept of a fair price under Delaware law on M&A. International Journal of Economic Theory 4(2):175–190. https://doi.org/10.1111/j.1742-7363.2008.00082.x

Yano M (2009) The Foundation of Market Quality Economics. Jpn Econ Rev 60(1):1–32. https://doi.org/10.1111/j.1468-5876.2008.00471.x

Yodo M, Yano M, (2017) Household Income and the OECD's Four Types of Social Capital, RIETI Discussion Paper, 17-E-119.

Yodo M, Yano M (2021) The OECD's Classification of Social Capital and Its Measures. mimeo., Kyoto University.

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Professor Matsuda is Chevalier de l'Ordre National du Mérite.

Chapter 9
Socio-Life Scientific Survey on COVID-19

Shigeru Hirota, Kazuya Setoh, Masato Yodo, and Makoto Yano

Abstract In overcoming the COVID-19 crisis, contribution from social science is indispensable as well as medical research. With this consideration, we have initiated a socio-life scientific survey on COVID-19, which is associated with the antibody test for the virus, targeting 3000 participants of the *Nagahama Survey* and 1000 medical workers at the Kyoto University Hospital. The survey is designed to highlight respondents' changes in behavior, the effect of the COVID-19 outbreak on respondents' values, and the actual spread of COVID-19 among the respondents.

Keywords COVID-19 · Behaviour change · Antibody test

JEL Classification I12

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1 Introduction

Since it was first confirmed in December 2019 by Chinese health authorities,[1] COVID-19 has rapidly spread all over the world.[2] In March 2020, many European countries were locked down until May or June.[3] Similarly, in the US, President Trump declared a national emergency.[4] In this process, it has been revealed that elderlies and those with underlying illnesses tend to suffer from more severe illness.[5] Since then, medical research on COVID-19 has rapidly progressed, and various treatments have been developed; the quick recovery of President Trump from COVID-19 infection has been attributed to a new medicine treatment based on dexamethasone, Regeneron's monoclonal antibody therapy, and remdesivir.[6] Despite all these efforts, however, 70.1 million people have been infected worldwide, with about 1.59 million dead as of December 12, 2020.[7]

While medical research is a key to containing the COVID-19 outbreak, social science provides another key. An early study of Yano (2021) shows evidence supporting that political leadership and social learning matter in controlling the spread of COVID-19 infection. Focusing on the early outbreaks in Florida, he shows that the virus spread more in counties in which more voters support President Trump, who downplayed the danger of the virus, and that the spread is less serious in middle to small cities than in countryside. At the same time, many observers relate the increase in the number of suicides in Japan and Korea during the summer of 2020 to the fact that the economic and social state of women was most severely hit by COVID-19.[8]

With these considerations, a group of social scientists at the Research Institute of Economy, Trade, and Industry (RIETI) and life scientists at the Graduate School of Medicine, Kyoto University, has initiated a socio-life scientific survey on COVID-19, targeting 3000 participants of the *Nagahama Survey* and 1000 medical workers at the Kyoto University Hospital. The survey is associated with the antibody test of COVID-19 administered to the respondents on the socio-life scientific survey. Although the survey can be adopted for various research theme, it is designed to highlight, in particular, behaviour change in the face of a pandemic in general, the effect on a system of values of the COVID-19 outbreak, and the actual spread of COVID-19 among the respondents.

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[1] See Shumaker (2020).

[2] See Johns Hopkins Site, https://coronavirus.jhu.edu/map.html.

[3] Lockdown started on March 23, 2020 in UK, and lasted until the beginning of June (Steed and Cavanagh 2020). In Italy, it first started in February 21. France and Spain joined on March 14. See Reuters Staff (2020).

[4] See Proclamation on Declaring a National Emergency Concerning the Novel Coronavirus Disease (COVID-19) Outbreak, issued on March 13, 2020. See the White House Site.

[5] See Huang et al. (2020).

[6] See Gallagher (2020).

[7] See Johns Hopkins site, https://coronavirus.jhu.edu/map.html.

[8] See Denyer and Kashiwagi (2020) and Wang et al. (2020).

The primary purpose of our survey is to find what may determine people's propensity to behaviour change in the face of a pandemic. A more specific research questions could be: Is behavior change attributable to the state of health or to individual characteristics such as education, age, and the sensitivity to social pressures and to persuasion? Our experience shows that in order to prepare against the next pandemic, it is highly important to find what contributes to behaviour change. The outbreak of COVID-19 has shown that behaviour change is difficult not only for ordinary people but also political leaders. This fact was suggested as early as April 2020. Focusing on the 2016 US presidential election and the 2018 Florida gubernatorial election, Yano (2021) shows that the number of COVID-19 cases in April is positively correlated to the county-by-county number of votes received by the Republican candidate, Governor DeSantis, whose policy is closely in line with President Trump, heavily downplaying the potential danger of COVID-19. A similar relationship is not observed in Ohio, in which the Republican candidate, Governor Dewine, was elected in 2018; it has been known that Governor Dewine has kept a distance from President Trump. This finding is confirmed by the recent spread of COVID-19 in South Dakota and Vermont. A video posted by the Recount shows that since March 2020, the COVID-19 outbreak have followed completely different paths between South Dakota, in which the state governor downplayed the danger of COVID-19, and Vermont, in which the governor has taken a very careful approach, even though the two states are similar in size and in that both governors are Republican.[9] As of December 2, 2020, 80,912 people have contracted the virus with 948 deaths in South Dakota whereas 4239 have contracted it with 72 deaths in Vermont. By now, it is widely acknowledged that masks are important in dealing with the COVID-19 outbreak. Starting with the US, despite this, many countries are struggling to convince their people of the use of masks. This suggests how difficult a behaviour change is for some people, including leading politicians. These considerations are reflected in the design of our survey.

The secondary purpose of our survey is to look into the effect of the COVID-19 outbreak on the Japanese system of values. In order to compare different values across time and regions, Hirota et al. (2020) adopt what they call a system of values, which is defined as a functional relationship between an individual's well-being and all the objective individual characteristics determining his well-being. Should, for example, the increase in the number of female suicides in Japan be in fact attributable to the COVID-19 outbreak, the change must somehow be reflected in the system of values. In order to capture such a change, panel data is necessary that makes it possible to compare people's well-being before and after the outbreak. Our COVID-19 data is designed in such a way that it may constitute panel data with the socio-life science surveys that we have compiled in Nagahama since 2016.

Our survey is also designed to study the determinants of the COVID-19 outbreak itself. For that purpose, we conduct antibody tests for some 3000 *Nagahama Survey* participants and 1000 medical workers at the Kyoto University Hospital. In Nagahama city so far, 53 cases have been reported since March 2020, which is 0.045% of

[9] The population of South Dakota and Vermont is about 900,000 and 624,000 respectively.

the Nagahama population; in contrast, in Kyoto city, 2018 cases have been reported, which is 0.14% of the Kyoto city population. At these ratios, we expect 1.4 cases either for the Nagahama respondents or for the Kyoto University medical worker respondents. Because our test is to detect the presence of COVID-19 antibodies, we may capture asymptomatic cases as well. Altogether, we hope to capture, for example, risk factors for each group of respondents.

In what follows, we explain the overall design of our survey in Sect. 2 and the survey questions and ideas behind them in Sect. 3. The actual survey questions and the options for answers are listed in the appendix, although its design differs from that of the actual survey, which was conducted online.

2 Overview of the Survey

Our survey questions can roughly be classified into two types. The first type consists of questions concerning what we want to explain by using our data (dependent variables). They are: those to capture behaviour change, those designed to measure well-being in the standard literature, and the results of COVID-19 and other antibody tests. The second type consists of those capturing factors that may explain a dependent variable. They are: basic individual characteristics such as age, family structure, etc., risk attitudes.

The survey covers two different groups of people. The first group consists of participants of the *Nagahama Survey*. The second group consists of medical workers at the Kyoto University Hospital.

2.1 Nagahama Group

As is discussed in Setoh and Matsuda (2021), the *Nagahama Survey* was started in 2007 to compile cohort data covering genomic and medical treats of people living in the city of Nagahama. In 2016, social scientific survey questions were added to capture the total aspect of human life. An individual's medical history may affect his lifestyle and way of thinking at the same time that an individual's economic status may influence his health. The current *Nagahama Survey* aims to capture this interaction between life scientific and social scientific aspects of life. As is discussed in Yano et al. (2021), Nagahama is a typical Japanese local city, in which the mobility of population is relatively low and in which traditional lifestyle is preserved.

As is discussed in Setoh and Matsuda (2021), the *Nagahama Genome Cohort Survey* was conducted in three waves. We conduct our survey online. The survey selects participants from the 10,115 people who participated in the second wave (2012–2016). We solicit participants who can participate in the online survey by announcing it through the local newspaper. Of these people, we randomly select 3000. In this selection, we exclude those who moved out of the Nagahama city, who refused the external management of medical examination information, those who withdrew their consent. After randomly dividing these 3000 participants into three groups of 1000 individuals, we conduct the questionnaire survey and the antibody test for each group in sequence in two- or three-week intervals.

2.2 Medical Workers Group

In contrast, medical workers are expected to be from many different parts of Japan, representing many different value systems. By investigating the determinants of behaviour change for this group of people, we may form a point of reference to make a comparison with the Nagahama group. Since the start of the outbreak, moreover, they have been exposed to the COVID-19 virus much more than those in the Nagahama group. By including the medical workers group, we may capture the relationship between behaviour change and COVID-19 much more clearly than in the Nagahama group.

Of the medical professionals working at Kyoto University Hospital, about 1000 people who agree with the purpose of this research and agree to participate are targeted. They are surveyed multiple times (about four times as a guide) to determine the presence or absence of COVID-19 antibodies, persistent infections, and reinfections. Multiple surveys will be conducted as follow-up surveys for the same subject.

2.3 Survey Method

Information on survey is delivered to potential participants, who are asked to express their willingness to participate through our website. The selected participants are asked to answer our survey questionnaire. To those who complete the questionnaire, we send equipment to collect saliva for the Nagahama group and blood for the medical workers group in order to conduct the antibody test. Survey participants will return the saliva sample in the enclosed return envelope according to the procedure manual. The test results are returned to participants in a secure manner by means of blockchain technology.

3 Survey Questions

Our survey questions can be divided into two types. The first type is primarily for dependent variables. The second type is primarily for explanatory variables. In addition, we ask a respondent’s personal views on various issues, which could be used as either dependent or explanatory variables. An English translation of the survey is set out in the appendix.

3.1 Primarily as Dependent Variables

3.1.1 Behaviour Change

As is discussed in the introduction, the primary purpose of the survey is to investigate what contributes to behaviour change. In order to capture the way in which people change their behaviour, we ask a number of questions.

In order to take into account the effect of the nationwide state of emergence starting on April 16, 2020, and being lifted at different time points in May in different prefectures, we divide the time period into five subperiods and ask respondents to answer the behaviour change related questions for each period. The five subperiods are (1) the period before the state of emergence (April 16), (2) the period from April 16 through the dates on which the state of emergency was lifted, which were May 14 in Shiga prefecture (where Nagahama is), and May 21 in Kyoto prefecture (where the Kyoto University Hospital is), (3) after the state of emergency was lifted through June 30 by when the outbreak first subsided, (4) from July 1, when the outbreak restarted through one month prior to the survey, and (5) for one month prior to the survey questions are answered. Note that, after July 1, the number of COVID cases hit a peak in August and stayed relatively low in September and October. It started to rise again after November. Most questions concerning behaviour change are asked for each of these periods.

A. Changes in the frequency and ways in which daily activities are conducted

We ask if a respondent, facing the COVID-19 outbreak, has changed the frequency with which he/she engages in the following activities (increased/unchanged/decreased/stopped) and the precautions that a respondent took: general outings (Q8, Q9), outdoor exercise such as walking and jogging (Q11, Q12), drinking out and eating out with friends (Q14, Q15), non-urgent hospital visits (Q17, Q18), visits to parents (Q20, Q21), visits to karaoke, live houses, and game arcades (Q23, Q24), and shopping (Q26, Q27). The selections for precautions we offer in our survey vary according to the nature of activity.

We ask why a respondent chooses to, or not to, use a mask. As a reason why he/she uses a mask, a respondent is asked to rate how closely each of the following reasons holds true: “to prevent infection”, “to prevent infection to others”, and “because people around me wear them”, “because someone told me to wear it”, “because I would be criticized without a mask”, and “because I usually wear it”. As a reason why he/she does not use a mask, we present the following reasons. “Because I don’t think it works”, “because it was too expensive”, “because masks are unavailable”, "because it is uncomfortable", "because it does not look good", and "because it is unlikely that I will get infected".

We also ask if the frequency of walking, biking, driving, and using taxis, buses and trains has changed compared to before the spread of COVID-19 infection.

B. More careful daily conducts

We ask to what extent a respondent engages in activities to avoid infected. They are: washing hands, disinfect fingers, gargling, taking a temperature often, sunbathing, covering the mouth when coughing or sneezing, avoiding to touch the mouth or nose, not rubbing eyes, sleeping well, wearing a product that claims to disinfect the space, wearing a mask when going out, and taking enough space at the cash register. Although some of these are medically questionable, they are intentionally included to observe how much medical knowledge a respondent may have. For each of these items, we ask about the extent to which a respondent was concerned (not at all/not so much/to some extent/as much as possible).

C. Travelling between badly and not badly affected areas

Whether or not one abstains from visiting areas in which COVID-19 spread badly may be an important measure to capture people's willingness to change behaviour. With this consideration, we ask whether a respondent travelled to areas in which COVID-19 spread. That is, we ask whether a respondent has travelled or planned to travel to the eight prefectures in which COVID-19 badly spread (Tokyo, Hokkaido, Saitama, Chiba, Kanagawa, Osaka, Kyoto, and Hyogo); the options for an answer are: yes and no.

In order to assist the tourism industry, on July 22, 2020, the government launched the "Go To Travel" campaign under which the government subsidizes half of the domestic travel cost. We ask whether a respondent has travelled or planned to travel after July 22 by using the "Go To" subsidy. To those who answer yes, we ask if the respondent would travel or plan to travel even if the campaign did not start.

3.1.2 Well-Being

As is noted above, a system of values is defined as a functional relationship between people's well-being and its determinants. In order to capture the way in which the COVID-19 outbreak affects the Japanese system of values, we ask questions focusing on people's well-being, the dependent variable in a system of values.

As an index characterizing well-being, we adopt happiness and life-satisfaction. The question to measure happiness is: "How happy are you now?" We also ask about future happiness five years from now and life satisfaction. The question for life satisfaction is: "Overall, how satisfied are you with life as a whole these days?" These questions are recommended by the Organisation for Economic Co-operation and Development; see Annex B of OECD (2013). In addition, we ask about subjective health by the following question: "How would you rate your general health status?"

Self-rated or self-assessed health that is asked by this type of questions has been widely used to measure an individual's general health status and has been shown to be a powerful predictor of future morbidity and mortality.[10] A respondent is asked to rate the answers to the first two questions by 0 through 10 and the last question by five levels.

3.1.3 COVID-19 Antibody Test

As is noted above, in our research project, we offer respondents COVID-19 antibody tests to respondents. Its primary purpose is, obviously, to see how the virus is spread in a typical mid-size city (Nagahama) relative to a major city (Kyoto) and to medical workers in the major city. At the same time, we hope to attract more people to participate in our survey by offering an antibody test. Moreover, we may be able to explain the COVID-19 spread by means of various social scientific factors, including people's readiness towards behaviour change. One caveat is, as is noted above, that the number of respondents who have COVID-19 antibody may be rather small.

3.2 Primarily as Explanatory Variables

We ask many types of questions to obtain different explanatory variables. They are basic characteristics of respondents, work, and economic status.

3.2.1 Basic Characteristics of Respondents

We ask about basic individual characteristics, including age, gender, and family structure. In addition to the basic family structure, we ask if a respondent has preschoolers and grandchildren living together. Moreover, in consideration of high COVID-19 risk groups, we ask if a respondent lives with people of age 65 and over and/or with underlying health problems (diabetes, heart failure, respiratory diseases, etc.). Moreover, we ask if a respondent lives with someone who needs dialysis or takes immunosuppressive or anti-cancer drugs. We also ask about basic characteristics on health and lifestyle, including subjective health, the K6 index[11] measuring depression, drinking/smoking habits, and attitudes towards risks.

[10] For example, see Mossey and Shapiro (1982) and Idler and Angel (1990).

[11] See Kessler et al. (2002).

3.2.2 Work and Economic Status

We ask a respondent's job status: The options for answer are: no jobs (meaning full-time housewives, students, and retired), employees, self-employed (operating restaurants, wholesale retailers, agriculture, etc.), professionals (doctors, lawyers, accountants, tax accountants, writers, etc.), employees of a family business (restaurants, wholesale retailers, agriculture, etc.), home-based work/internal work that has no employment relationship with a company, consignment/contract worker (without long-term employment relationship). Moreover, we ask if a respondent has a job that requires to make a direct contact with customers (floor staff, cash register staff, etc.) and if he has a job to provide face-to-face customer services at eateries (waiters, waitresses, etc.). We also ask the average number of people with whom a respondent makes direct contacts for colleagues, clients, and customers.

With respect to remote work and flexible time commuting, which has become popular due to the pandemic, we ask if a respondent is encouraged at the workplace (not encouraged at all/not so encouraged/neither encouraged nor discouraged/more or less encouraged/highly encouraged), how often the respondent takes up such an option (almost never/about one to two days a week/about three days a week/more than four days a week), and if he wants to have more or less opportunities for remote work/flexible time commuting.

We also ask about average weekly working hours, annual household income, and household wealth balance.

3.2.3 Risk Attitude

In the face of COVID-19, one's readiness towards behaviour change may closely be related to one's attitudes towards risk. With this consideration, we ask a couple of questions to quantify risk attitude.

The first question is as follows: "On the one hand, we have a saying that 'nothing ventured, nothing gained.' At the same time, we also have a saying that 'a wise man keeps away from danger.' Which do you think you are closer when you choose your own action?" A respondent is asked to identify which of these statements better describes their view. The other question is: "What is the probability of rain above which you take an umbrella when go out." A respondent is asked to choose from 0, 10, 20 to 100%.[12]

As related questions, we ask if a respondent agrees with the following statements. "In general, I feel very positive about myself", "I'm always optimistic about my future", "I am free to decide for myself how to live my life", "I generally feel that what I do in my life is worthwhile", "Most days I get a sense of accomplishment

[12] This type of question on individual's risk attitude is introduced in a survey named *Survey on Life and Society* (Kurashi to Shakai ni Kansuru Ankeito) by a University of Osaka study group. See www.econ.osaka-u.ac.jp/ohtake/survey/kogakusyotoku.pdf. For more information, see Ohtake and Tomioka (2004), p. 343.

from what I do", "When things go wrong in my life it generally takes me a long time to get back to normal", "I try to live free from social constraints".[13]

3.2.4 Basic Health

State of health is also an important factor relating to behaviour change. In order to estimate a stable system of values, it may be important to control one's physical health, which may affect one's view on well-being temporarily.

With these considerations, we ask if a respondent has various symptoms, such as sore throat, fever, fatigue, and stomach ache. We also ask if a respondent suffer from various illness in 2020, including flu, COVID-19, ordinary cold, allergy, and asthma and if he has more basic health problems such as diabetes, high cholesterol, high blood pressure, respiratory disorders, etc. These questions also serve as explanatory variables for COVID-19 infection.

3.3 Additional Questions

In addition, we ask a respondent's personal views on various aspects of life. Some of those questions are concerned with how people should live in the face of COVID-19. Others are concerned with one's social capital. These questions can be, in and of themselves, something to be explained. At the same time, they can serve as explanatory (control) variables in explaining behaviour change and the system of values.

3.3.1 Personal Views on COVID-19

We ask a number of questions to capture a respondent's views on COVID-19. First, we ask a respondent to evaluate the national and local governments' dealings with COVID-19 outbreak. We also ask if a respondent thinks that the outbreak can be controlled if people simply follow governmental guidelines, which sources he relied on to obtain information on COVID-19 (friends/acquaintances, family, magazines/books, newspapers/TV, SNS, web information (news), web information (administrative agencies)), and the extent to which he rely on those sources.

We investigate how individuals view social restrictions on individual activities. That is, a respondent is asked to what extent he is uncomfortable with, or unhappy about, those who do not heed to social distancing in cases such as waiting to check out at a supermarket, whether he believes that those who caught COVID-19 can be socially criticized, and whether he supports making the use of a mask mandatory, prohibiting parties, and, more generally, restricting personal freedom.

[13] These questions, except for the last one, are from Eudaimonic questions in Annex B of OECD (2013). The last one is an original question to investigate people's attitude toward peer pressure.

We also ask if a respondent is usually vaccinated against the flu and if he wants to take a COVID-19 vaccine, if it becomes available.

3.3.2 General Temperament and Sociality

The survey includes some questions on general temperament and sociality. In relation to behaviour change, we ask if a respondent has a mental block against starting new activities such as visiting a new store and adopting new technology (for example, smartphone, online meeting). In addition, we ask if a respondent is reluctant to change his daily activities even if he knows he should change.

We measure social capital by means of standard questions recommended by the OECD (Scrivens and Smith 2013; Yodo and Yano 2017). On the trust one would have towards others in general, we ask if a respondent thinks that most people can be trusted or that it is more prudent to be careful in interacting with others. To measure social capital related to networks, we ask how reliable a respondent finds neighbours, relatives, and colleagues at work to confide daily problems and concerns, and the frequency with which he interacts with those group of people. We also ask the level of trust a respondent has in each of the national government, local governments, scientists such as infectious disease specialists, and news media such as broadcasters and newspapers. In addition, we ask about the donations that a respondent made in the last 12 months.

Appendix: Socio-Life Science Questionnaire on COVID-19 Outbreak

Q1	How long have you had continuously the following symptoms since January 2020?
	• Sore throat • Cough • Sneezing and runny nose • Low fever (below 37.5°) • High fever (37.5° or higher) • Feeling chill • Short breath • General fatigue • Stomach ache
	1: Never 2: One to three days 3: Four to seven days 4: More than a week

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Q2	When did you have the symptoms above? Please indicate all that are applicable.[14]
Q3	What action did you take when you had a symptom in the previous question? If you have more than one option that describes your action, please mark all that are correct descriptions.
	1: I did not do anything particular 2: I stayed at home to recover 3: I visited a doctor 4: I suspected a COVID-19 infection and consulted with a government and a governmental health service 5: Following a governmental health service's advice, I took a PCR test
Q4	What was the diagnosis?
	1: Flu 2: COVID-19 3: Ordinary cold 4: Pollen allergy 5: Asthma
Q5	Do you suffer from the following health problems?
	• Diabetes • Hyperlipidemia (high cholesterol, high triglyceride) • Hypertension • Stroke (cerebral infarction/hemorrhage). • Respiratory disorders (asthma, chronic obstructive pulmonary disease (COPD)) • Angina/myocardial infarction/heart failure • Dialysis • Immunosuppressant/anti-cancer drugs
Q6	Since January 2020, have you travelled to the area in which COVID-19 badly spread (Hokkaido, Saitama, Chiba, Tokyo, Kanagawa, Osaka, Kyoto and Hyogo) except for commuting?
	0: Never 1: One to four times 2: Five to nine times 3: More than nine times
Q7	When did you travel? Please choose all applicable. (See footnote 14 for the periods)
Q8	In each of the following periods (see footnote 14 for the periods), did you change the frequency of going out?

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[14] In this survey, we divide the period of the outbreak into the following subperiods and ask respondents to answer the behavior change related questions for each subperiod.

1. Before the state of emergency was issued.
2. During the state of emergency (April 16 through May 14 in Shiga and May 21 in Kyoto).
3. After the state of emergency through the end of June.
4. July through a month ago.
5. Since a month ago.

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	1: Increased 2: Not changed 3: Decreased 4: Stopped 5: I have been housebound
Q9	In each of the following periods (see footnote 14 for the periods), did you take precautions below? Please indicate all.
	0: Took no precaution 1: Used a mask 2: Chose a non-crowded period 3: Other precautions
Q10	To what extent are you reluctant to do the following activities? Please indicate the level between 0 (not at all) and 10 (very much).
	• Going out using a mask • Going out during a non-crowded period
Q11	In each of the following periods (see footnote 14 for the periods), did you change the frequency of outdoor exercises such as walking and jogging?
	1: Increased 2: Not changed 3: Decreased 4: Stopped 5: I do not exercise
Q12	When you exercise, did you take any precaution?
	0: Took no precaution 1: Used a mask 2: Chose a non-crowded period 3: Other precautions
Q13	To what extent are you reluctant to do the following activities? Please indicate the level between 0 (not at all) and 10 (very much).
	• Exercising using a mask • Exercising during a non-crowded period
Q14	In each of the following periods (see footnote 14 for the periods), did you change the frequency of drinking and eating out with friends?
	1: Increased 2: Not changed 3: Decreased 4: Stopped 5: I do not eat out
Q15	What sort of precautions did you take?
	1: Used a mask 2: Chose a non-crowded time 3: Did it online 4: Other precautions 5: Took no precaution
Q16	To what extent are you reluctant to do the following activities? Please indicate the level between 0 (not at all) and 10 (very much).

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	• Drinking and eating out with friends using a mask • Drinking and eating out with friends during a non-crowded period • Drinking and eating out with friends online
Q17	In each of the following periods (see footnote 14 for the periods), did you change the frequency of visiting a hospital and a clinic for a non-urgent purpose?
	1: Increased 2: Not changed 3: Decreased 4: Stopped 5: I do not make a doctor visit
Q18	What sort of precautions did you take?
	1: Used a mask 2: Chose a non-crowded time 3: Did it online 4: Other precautions 5: Took no precaution
Q19	To what extent are you reluctant to do the following activities? Please indicate the level between 0 (not at all) and 10 (very much).
	• Visiting a hospital and a clinic with friends using a mask • Visiting a hospital and a clinic during a non-crowded period • Having a consultation online
Q20	In each of the following periods (see footnote 14 for the periods), did you change the frequency of visiting your parents' home?
	1: Increased 2: Not changed 3: Decreased 4: Stopped 5: I do not visit parents
Q21	What sort of precautions did you take?
	1: Used a mask 2: Chose a non-crowded time 3: Did it online 4: Other precautions 5: Took no precaution
Q22	To what extent are you reluctant to do the following activities? Please indicate the level between 0 (not at all) and 10 (very much).
	• Visiting your parents' home using a mask • Visiting your parents' home during a non-crowded period • See your parents online
Q23	In each of the following periods (see footnote 14 for the periods), did you change the frequency of visiting such a pleasure facility as a Karaoke bar, a live music house, and a game center?

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	1: Increased 2: Not changed 3: Decreased 4: Stopped 5: I do not use these facilities
Q24	What sort of precautions did you take?
	1: Used a mask 2: Chose a non-crowded time 3: Other precautions 4: Took no precaution
Q25	To what extent are you reluctant to do the following activities? Please indicate the level between 0 (not at all) and 10 (very much).
	• Visiting a pleasure facility using a mask • Visiting a pleasure facility during a non-crowded period
Q26	In each of the following periods (see footnote 14 for the periods), did you change the frequency of shopping?
	1: Increased 2: Not changed 3: Decreased 4: Stopped 5: I do not go out for shopping
Q27	What sort of precautions did you take?
	1: Used a mask 2: Chose a non-crowded time 3: Shopped online or by mail order 4: Other precautions 5: Took no precaution
Q28	In each of the periods in 2020 (see footnote 14 for the periods), how often did contact with people (excluding passers by) with the following symptoms?
	• Sore throat, coughs, sneezes, and/or short breath • Fever of 37.5° or higher • COVID-19 infection • Closely in touch with a COVID-19 patient
	0: Never 1: Less than once a month 2: Once to three times 3: Less than four times a week 4: Four times or more
Q29	In your daily life, how did you deal with the following health precautions? Please answer for the following periods (see footnote 14 for the periods).

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	• Washing hands • Disinfecting hands by alcohol etc • Gargling • Taking temperature frequently • Sunbathing a lot • Covering your mouth by hands when coughing and sneezing • Trying not to touch mouth and nose • Trying not to rub eyes • Sleeping sufficiently • Waring products that are for disinfecting air • Using a mask when going out • Observing a social distance when lining up for a cashier at shops
	1: Did not attempt intentionally at all 2: Did not attempt so ardently 3: Did attempt somewhat seriously 4: Did attempt very seriously
Q30	What sort of precautions did you take when washing hands?
	1: Washing hands with water 2: Using soap to wash hands 3: Washing hands for a longer time 4: Washing more carefully 5: Washing more often 6: Washing every time after going out 7: Washing the sides of fingers and lists intensively
Q31	What sort of precautions did you take when disinfecting hands?
	1: Using hand sanitizers offered by shops 2: Carrying your own hand sanitizer 3: Using ultraviolet sanitizers
Q32	What sort of precautions did you take when gargling?
	1: Taking a longer time 2: Gargling more often 3: Using a hot water 4: Using a medicine for gargling 5: Using salt water
Q33	Why did you not use a mask when going out?
	• A mask is ineffective against COVID-19 • I did not feel to buy a mask for it was too expensive • I wanted to use a mask but could not get it • A mask makes me uncomfortable (hot, itchy) • A mask makes me look bad, for it is not fashionable • I do not believe that I will catch it, for I am very healthy and strong
	1: This is absolutely not the reason 2: This is not really a reason 3: I do not know if this is a reason 4: This is a relatively strong reason 5: This is a strong reason
Q34	Tell us why you use a mask.

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	• To avoid catching COVID-19 • Because I am afraid to giving the virus to others • Because many people around me are using it • Because my family member or a friend advise me to use it • Because I am afraid of criticized if I do not use it • I am used to use a mask, for example, to protect against cedar pollen and other allergy
	1: This is absolutely not the reason 2: This is not really a reason 3: I do not know if this is a reason 4: This is a relatively strong reason 5: This is a strong reason
Q35	To what extent did you rely on the information from the following sources?
	• Friends and acquaintances • Family members • Magazines and books • Newspapers and TVs • Private web sites and SNS • Web news • Governmental and organizational web sites
	1: Not at all 2: Rarely 3: Somewhat 4: Very much
Q36	How do you rate a government's initiatives to cope with COVID-19?
	1: Extremely satisfied 2: Moderately satisfied 3: Neither 4: Moderately dissatisfied 5: Extremely dissatisfied
Q37	How do you rate a local government's initiatives to cope with COVID-19?
	1: Extremely satisfied 2: Moderately satisfied 3: Neither 4: Moderately dissatisfied 5: Extremely dissatisfied
Q38	To what extend do you agree with the statement that you can avoid catching COVID-19 if you follow what the government tells you to do?
	1: I agree absolutely 2: I agree basically 3: I neither agree not disagree 4: I disagree basically 5: I disagree absolutely
Q39	Per capita, the number of PCR tests conducted in Japan is lower than those in many other countries. What is you view on PCR test? Please choose the one close to your view.

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	1: The number of PCR tests should be increased to understand the spread of the virus 2: The government should be careful in increasing the number of PCR tests because there can be many pseudo negatives and pseudo positives cases, which would cause an unnecessary confusion among the public
	3: I cannot either/I do not know
Q40	Do you take flu shots?
	1: Every year 2: Some years 3: Rarely
	4: I do not want to take flu shot 5: I cannot take flu shots because of medical reasons such as allergies
Q41	Did you take flu shots this season (fall and winter)?
	1: I did 2: I will 3: I will not
Q42	“The Go To Travel campaign”, during which the government pays half of a domestic travel expense, started on July 22. Since the start of the campaign, have you made a trip (including a day trip), or planned to make a trip, outside of the prefecture you live(d)?
	1. I have either made a trip or planned a trip 2. I have neither made a trip nor planned a trip
Q43	If you choose 1 in the above question, would you have made, or planned, the trip even if the Go To Travel campaign were not adopted?
	1. I would have not made the trip 2. I would have made the trip 3. I do not know
Q44	Are there anyone close to you (family members, relatives, friends, colleagues, neighbors) who caught COVID-19?
	1: Yes 2: No
Q45	When did the person(s) catch COVID-19? If more than one person caught the virus, please tell us the earliest case. (See footnote 14 for the periods.)
Q46	Are you upset when you see people who are not keeping a sufficient distance in a place where many people gather (such as a line for a cashier)?
	1: Yes 2: Somewhat yes 3: It does not bother me
Q47	Do you think it justifiable that people criticize those who caught COVID-19 in the current circumstances in which many people put various efforts to contain the virus?
	1: It is justifiable 2: It is somewhat justifiable 3: It is not justifiable 4: It is unforgivable to criticize people for that reason
Q48	Please choose the option that best describes your view on each of the following statements.

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	• We should restrict travels of outside people to our area so as to control the spread of COVID-19 in our area • It is better to restrict to one's freedom, such as requiring the use of a mask and prohibiting drinking parties, so as to contain the outbreak of COVID-19
	1: I do not agree at all 2: I somewhat disagree 3: I somewhat agree 4: I absolutely agree
Q49	On your current work, please tell us a type of job. [Only for Nagahama group]
	1: No jobs (full-time housewives, students, retired) 2: Employees having a formal contract with the employer 3: Self-employed (operating restaurants, wholesale retailers, agriculture, etc.) 4: Professionals (doctors, lawyers, accountants, tax accountants, writers, etc.) 5: Employees of a family business 6: Home-based work/internal work, non-employee 7: Contract workers, non-employee 8: Do not want to answer
Q50	On your current work, please tell us a type of job. [Only for medical workers group]
	1: Doctor, dentist 2: Nurse, midwife 3: Pharmacist 4: Clinical laboratory technician, clinical engineer, vision trainer 5: Physiotherapist, occupational therapist 6: Radiological technologist 7: Medical information manager, medical information technologist 8: Medical administrator, medical secretary 9: Other types of medical work 10: Do not want to answer
Q51	Do you have a job that requires to make a direct contact with customers?
	1. Retail store staff (floor staff and cash register staff) 2. Customer service at restaurants and bars (waiter or waitress) 3. Customer service requiring personal contacts with customers 4. My job does not require direct personal contacts
Q52	In which area is your workplace located?
	1: Nagahama city, Shiga prefecture 2: Other cities than Nagahama, Shiga prefecture 3: Kyoto prefecture 4: Osaka prefecture 5: Nara prefecture 6: Hyogo prefecture 7: Aichi prefecture 8: Tokyo, Kanagawa, Chiba, Saitama prefecture or Hokkaido 9: Other prefectures
Q53	Can your work be conducted remote from home?
	1: Impossible 2: Partially possible 3: It can easily be shifted

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Q54	Can your work permit off-peak-time commuting?
	1: Impossible 2: Partially possible 3: It can easily be shifted
Q55	In each of the following periods (see footnote 14 for the periods), were you encouraged by your workplace to go remote?
	1: Not all encouraged 2: Not so encouraged 3: Neither encouraged nor discouraged 4: Somewhat encouraged 5: Strongly encouraged
Q56	In each of the following periods (see footnote 14 for the periods), were you encouraged to go off-peak-time commuting?
	1: Not all encouraged 2: Not so encouraged 3: Neither encouraged nor discouraged 4: Somewhat encouraged 5: Strongly encouraged
Q57	How often did you work remote? (See footnote 14 for the periods)
	1: Almost never 2: One or two days a week 3: Three days a week 4: More than for days a week
Q58	How often did you commute off-peak time? (See footnote 14 for the periods)
	1: Almost never 2: One or two days a week 3: Three days a week 4: More than for days a week
Q59	Do you want to work remote more?
	1: Want to reduce significantly 2: Want to reduce somewhat 3: I like the way it is now 4: I want to increase a bit 5: I want to increase a lot
Q60	Do you want to increase off-peak time commuting?
	1: Want to reduce significantly 2: Want to reduce somewhat 3: I like the way it is now 4: I want to increase a bit 5: I want to increase a lot
Q61	Please choose one option that fits most to your view and idea with respect to the following:

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	• I do not have any hesitancy to start new things (eg. try a newly opened store) and to use new technology (eg. online meetings and smart phone) • I hesitate to change daily habits even if I should change them • I tend to stick to what I have decided until something is accomplished • I think one of the most important things in life is not to be troublesome for others • I have a personality to do what is good for my health even if that would cause a pain either physically or mentally
	1: I do not agree at all 2: I somewhat disagree 3: I do not have any view 4: I somewhat agree 5: I absolutely agree
Q62	On the one hand, we have a saying that "nothing ventured, nothing gained." At the same time, we also have a saying that "a wise man keeps away from danger." Which do you think you are closer when you choose your own action?
	1: Nothing ventured, nothing gained 2: A wise man keeps away from danger
Q63	What is the probability of rain above which you take an umbrella when go out?
	0: 0% 1: 10% 2: 20% 3: 30% 4: 40% 5: 50% 6: 60% 7: 70% 8: 80% 9: 90% 10: 100%
Q64	During the last 30 days, about how often did you feel …
	• … nervous? • … hopeless? • … restless or fidgety? • … so depressed that nothing could cheer you up? • … that everything was an effort? • … worthless?
	1: Never 2: Rarely 3: Sometimes 4: Usually 5: Always
Q65	Next, we ask you about yourself and what you feel in your life. Please indicate how strong you feel from 1 to 10. 1 implies that you absolutely feel so. 10 implies that you do not feel so at all.

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	• In general, I feel very positive about myself • I'm always optimistic about my future • I am free to decide for myself how to live my life • I generally feel that what I do in my life is worthwhile • Most days I get a sense of accomplishment from what I do • When things go wrong in my life it generally takes me a long time to get back to normal • I try to live free from social constraints
Q66	How happy are you now? Please indicate the level between 1 (very unhappy) and 10 (very happy).
Q67	How happy do you think will you be five years later? Please indicate the level between 1 (very unhappy) and 10 (very happy).
Q68	Overall, how satisfied are you with life as a whole these days? Zero means you feel "not at all satisfied" and 10 means you feel "completely satisfied."
Q69	How would you rate your general health status?
	1: Very good 2: Quite good 3: Neither good nor poor 4: Quite poor 5: Very poor
Q70	Generally speaking, would you say that most people can be trusted? Or that you need to be careful in dealing with people? "Please indicate the number between 1 "Most people can be trusted" and 10 "You need to be very careful in dealing with people" that most closely describes your opinion by covering the number in black."
Q71	To what extent do you think you can count on the following people to seek for help to deal with daily problems and concerns?
	• Neighbors • Family members • Relatives • Friends • Workmates
	1. I can count on them a lot 2. I can count on them to some extent 3. I either can or cannot count on them 4. I cannot count on them so much 5. I cannot count on them at all 6. I have no such person
Q72	During the past year, have you donated money to a non-profit organization or an organization conducting charitable activities?
	1: None 2: Less than 1000 yen 3: 1000 yen through 4999 yen 4: 5000 yen through 9999 yen 5: 10,000 yen through 49,999 yen 6: 50,000 yen and more
Q73	How often do you usually associate with friends, relatives, or workmates?

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	• Friends and acquaintances (excluding classmates or work mates) • Relatives • Workmates
	1: Very often (once a day—several times a week) 2: Occasionally (once a week—several times a year) 3: Rarely (once a year—several times in several years) 4: Never 5: I do not have such a person
Q74	To what degree do you trust the following organizations?
	• Central government • Local governments • Scientists specializing in infectious diseases and other medical studies • TV and radio news media, newspapers
	1. I trust very much 2. I trust to a certain degree 3. I neither trust nor distrust 4. I do not trust much 5. I do not trust at all 6. I do not know
Q75	To what degree do you agree with the following statements?
	• If I help somebody out, when I am in difficulty, somebody will help me out • Most people are happy to help others
	1: I absolutely agree 2: I somewhat agree 3: I do not have any view 4: I somewhat disagree 5: I do not agree at all 6: I do not know
Q76	Please let us understand your family structure. Do you live with the following family members?
	• Spouse • Children • Grandchildren • Parents • Preschool children • Elderly adult (65 years and older) • Those who have basic health problems, including diabetes, heart failure, and respiratory disorders, receives dialysis, immunosuppressants, and anticancer agents
Q77	Please tell us a number of family members living with you (please do not include yourself).
Q78	Are you married?
	1: Married 2: Divorced 3: Separated by death 4: Never married 5: I do not want to answer
Q79	Do you smoke?

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	1: Yes 2: Not now, although I used to smoke 3. No
Q80	Do you drink?
	1: Not at all 2: Less than once a week 3: About once 4: About twice 5: About three times 6: About four times 7: About five times 8: About six times 9: Every day
Q81	If you drink, please let us know what you drink and how much a day. If you take different types of alcohol from one day to another, please tell us by the most usual daily combination.
	0. I do not drink 1. Less than a glass of wine 2. A glass of wine 3. Two glasses of wine 4. Half a bottle of wine 5. A bottle of wine 6. More than a bottle of wine
Q82	Have you changed the amount of alcohol drink you take a day?
	1. Decreased significantly 2. Decreased a bit 3. Unchanged 4. Increased a bit 5. Increased significantly
Q83	How many hours do you work to earn income? Please include overtime hours. If you have more than one job, please let us know the total work hours.
Q84	How often do you have personal contacts at workplace? Please let us know the average number of people a day for your colleagues and others such as customers and clients.
Q85	Which of the following corresponds to your household's annual income? Please include all the side-job income and various benefits etc. before you pay taxes and social insurance premiums.
	1:No more than 2 million yen 2:Greater than 2 million and no more than 4 million yen 3:Greater than 4 million and no more than 6 million yen 4:Greater than 6 million and no more than 8 million yen 5:Greater than 8 million and no more than 10 million yen 6:Greater than 10 million and no more than 15 million yen 7:Greater than 15 million yen 8:I do not know/I do not want to answer
Q86	Which of the following corresponds to your household's total present bank deposits, shares, and investment trusts?

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	1:No more than 2 million yen 2:Greater than 2 million and no more than 4 million yen 3:Greater than 4 million and no more than 6 million yen 4:Greater than 6 million and no more than 8 million yen 5:Greater than 8 million and no more than 10 million yen 6:Greater than 10 million and no more than 15 million yen 7:Greater than 15 million and no more than 20 million yen 8:Greater than 20 million yen 9:I do not know/I do not want to answer
Q87	Since when did your family live in the area where you currently live? Please answer about the father's side or mother's side who has lived in the area for a longer time.
	1: From my generation 2: From my parents' generation 3: From my grandparents' generation 4: From my great-grandparents' generation or earlier
Q88	Where did your family live before your family moved to your current area?
	1: Nagahama city 2: Shiga prefecture except for Nagahama city 3: Outside of Shiga prefecture 4: I do not know

References

Denyer S, Kashiwagi A (2020) Japan and South Korea see surge of suicides among young women, raising new questions about pandemic stress. Washington Post 29 Nov 2020. www.washingtonpost.com/world/asia_pacific/japan-suicides-pandemic-women/2020/11/28/0617e3a2-fdbd-11ea-b0e4-350e4e60cc91_story.html

Gallagher J (2020) Dexamethasone, remdesivir, Regeneron: trump's covid treatment explained. BBC News 9 Oct 2020. www.bbc.com/news/health-54418464

Hirota S, Yodo M, Sekine Y, Yano M (2020) Fukushima nuclear accident and the Japanese system of values. mimeo

Huang C, Wang Y, Li X et al (2020) Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet (Br Edn) 395:497–506

Idler EL, Angel RJ (1990) Self-rated health and mortality in the NHANES-I epidemiologic follow-up study. Am J Public Health 80(4):446–452. https://doi.org/10.2105/ajph.80.4.446

Kessler R, Andrews G, Colpe L, Hiripi E, Mroczek D, Normand S, Walters E, Zaslavsky A (2002) Short screening scales to monitor population prevalences and trends in non-specific psychological distress. Psychol Med 32(6):959–976

Mossey JM, Shapiro E (1982) Self-rated health: a predictor of mortality among the elderly. Am J Public Health 72:800–808

OECD (2013) OECD guidelines on measuring subjective well-being. OECD, Paris

Ohtake F, Tomioka J (2004) Who supports redistribution? Jpn Econ Rev 55:333–354

Reuters Staff (2020) Timeline—how the global coronavirus pandemic unfolded. Reuters 29 Sept 2020. www.reuters.com/article/health-coronavirus-timeline-idUSL1N2GN04J

Scrivens K, Smith C (2013) Four interpretations of social capital: an Agenda for measurement. OECD Publishing. https://doi.org/10.1787/5jzbcx010wmt-en

Setoh K, Matsuda F (2021) Cohort profile: the Nagahama prospective genome cohort for comprehensive human bioscience (The Nagahama Study). In: Yano M et al (eds) Socio-life science and the COVID-19 outbreak. Public Health and Public Policy, Springer

Shumaker E (2020) Timeline: how coronavirus got started—the outbreak spanning the globe began in December, in Wuhan, China. ABC News 23 Sept. https://abcnews.go.com/Health/timeline-coronavirus-started/story?id=6943516

Steed L, Cavanagh N (2020) When did lockdown start in the UK? The Sun, 17 Nov 2020. www.thesun.co.uk/news/11304061/uk-coronavirus-lockdown-month-lasted-start-end/

Wang S, Wright R, Watsuki Y (2020) In Japan, more people died from suicide last month than from Covid in all of 2020. And women have been impacted most. CNN, 30 Nov 2020. https://edition.cnn.com/2020/11/28/asia/japan-suicide-women-covid-dst-intl-hnk/index.html

Yano M (2021) COVID-19 pandemic and behavioural change: the cases of Florida and Ohio. In: Yano M et al (eds) Socio-life science and the COVID-19 outbreak. Public Health and Public Policy, Springer

Yano M, Hirota S, Yodo M, Matsuda F (2021) Nagahama survey on social science. In: Yano M et al (eds) Socio-life science and the COVID-19 outbreak. Public Health and Public Policy, Springer

Yodo M, Yano M (2017) Household income and the OECD's four types of social capital. RIETI Discussion Paper, 17-E-119

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Chapter 10
Sharing of Research Data by Blockchain

Chris Dai, Tadaaki Chigusa, and Makoto Yano

Abstract This study investigates the new method of sharing research data by a blockchain. We focus on the sharing not only among researchers but also between a group of researchers and test subjects from whom researchers collect data. To explain the use of blockchain technology, we explain the use of blockchain in securely handling research data in comparison with a simple real-world use case.

Keywords Research data · Blockchain · Data security

1 Introduction

Date sharing is one important issue faced by researchers building data covering both human health and behaviour. By data sharing, we do not simply mean the sharing of data among researchers, which is obviously highly important for us researchers. However, more important is the sharing of data between researchers and survey subjects. The latter issue would become sensitive when we deal with serious illness from which a person wants to hide the fact that he suffers or a person who can spread to others. In Japan, there remains serious social stigma attached to certain diseases. At the beginning of the COVID-19 outbreak, in Japan, those contracted Sars-Cov-2 were ostracized in certain traditional regions. Even if such a stigma is not attached to contraction of a disease, losing private data and misinforming subjects of wrong test results could be intolerable for test subjects. In these circumstances, there can be a strong hesitancy on the side of a data builder to inform test subjects a result of the test.

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It is our view that blockchain technology may drastically ease the possibility of malicious attacks, mistakes, and errors that may occur while researchers share data among researchers and with test subjects. Blockchain is a technology on decentralized computer networks that allows end producers of data to share their digital data among themselves in a secure manner (see Omote and Yano 2020, for an explanation on the technology). It is therefore natural that the standard blockchain technology lets researchers securely share their research data among themselves. Data sharing between researchers and test subjects is, however, different because of its nature and of possible test subjects' unfamiliarity with blockchain. To deal with the unique feature of researchers/test-subjects data sharing, we need a new type of blockchain application.

In this chapter, we introduce a design of such an application, with which data can be shared securely between researchers and test subjects as well as among researchers. In doing so, we explain how we should handle unique features in this type of data sharing through blockchain.

Blockchain is a new technology, with which many readers may be unfamiliar. Strong resistance exists among ordinary people who do not understand exactly what blockchain does, because it is a technology that supports crypto currency, and because, unfortunately, crypto currency is currently used as a device for speculation and shady transactions; if speculation and shady transactions subsided, crypto currency might replace the existing hard currencies (Yano 2020). For this reason, we start this study with explaining basic features of blockchain technology and present a use case.

2 Blockchain and Decentralized Data Ownership

Blockchain is a technology, or a computer algorithm, that makes it possible to assign a unique owner to each piece of data in a data file on the internet. For this purpose, many copies of a digital file are maintained independently at separate network computers. Supported by modern cryptography, blockchain algorithms ensure those copies are identical and secure in such a way that external attacks on the file are almost, if not totally, impossible (see Omote and Yano 2020, for more explanation). The mere fact that many internet users regard crypto currencies as a way to hold their assets attests that blockchain can establish the secure ownership of data, or records of past transactions.

2.1 Data Security and Data Privacy

"Files containing personal information on some 9500 people infected with the novel coronavirus in this western Japan prefecture were accessible to a third party online, the Fukuoka Prefectural Government revealed on Jan. 6" according to

Mainichi Japan, a Japanese national daily newspaper (Mainichi Japan 2021). The files contained names, addresses, and symptoms, and other information on COVID-19 infected residents in the prefecture were accessible to unintended third parties. Needless to say, this kind of information if leaked severely damages personal privacy and even causes possible harm to the people who submitted their personal information to the government.

This kind of information leakage is becoming more frequent as institutions such as government and companies push forward to digitize all data and allow online data access with related parties. At first glance, the problem is caused by a random operational error performed by careless staff. Some may even claim that the risk of such mistake is inherent in sharing data online through servers. But the real issue is that data is stored in one place with a single point of failure, in this case the Fukuoka prefectural government.[1] If someone within the government makes a mistake or the system has a small bug then it becomes a honey pot for outside attacks by hackers. How to solve this issue? Can we put multiple check processes in between to prevent such human error? As you remember in your high school physics class, the second law of thermodynamics states that the level of disorder in the universe is steadily increasing and hence systems most likely to move from order to disorder. You can think of a file management system as a centralized and highly ordered system. As time passes by, more users using the file management system will cause disorder to creep in and incidents will happen. Therefore, the real issue is how we can make a system that can counter disorder in the long run. The answer lies in a decentralized system where individuals, not a central data management entity, manages and controls their own data.

You may feel the centralized data storage used by the Fukuoka prefecture government has nothing to do with you. Consider the vast amount of personal data you share with internet platforms like Google, Amazon, Facebook, Apple, Microsoft, etc. Unlike the Fukuoka prefectural government that collected and shared data of COVID-19 infected patients for the social good, those internet platforms collect user data for just a single purpose of making a profit, as they should. And those data are also stored in centrally managed databases.

The issue of internet platforms storing your personal data goes beyond whether they are securely storing your data or not. Most people are not even aware what kind of data they have collected, how are those data being used, and for what purpose? You can get a glimpse of how important personal data can be for these platforms from a recent BBC report titled “Facebook pours fuel on Apple privacy row”. Earlier in 2020, Apple announced it would implement a new policy for its iPhone users to ask for permission to have part of the user data shared to enable targeted, personalized advertising. As its main revenue come from such advertising paid by third party advertisers, Facebook fear it will make targeted advertising difficult following Apple’s new policy because a great proportion of users will not give such permission. Facebook has put on a public offensive, including putting a full-page adverts

[1] See Yano et al. (2020) and Pu (2020) for further discussions on leaving a single point of failure unprotected in a network system.

in printed newspapers, to claim that Apple's new policy is hurting small businesses that utilize personalized advertising. It also alleged Apple's move is about forcing people to use Apple's own advertising platform.[2]

Watching two internet giants fight over whether to share users' personal data raises the question who really own the users' personal data? The official answer is, of course, the user owns his or her data. But, in reality, the data is stored in the internet platformers' database, and it is not easy to find out how that data is being used or even leaked. To counter this problem, a decentralized data ownership model should be devised. A decentralized data ownership model is inherently more secure in its architecture, as data is distributed between many individuals and has no single point of failure. It is also more resistant to hacking because, instead of breaking into one system, hackers need to break into all the individual systems to collect all the data, which makes it much less desirable as an attack target. To make individual ownership of data in the true sense, we need a new system model different from the centralized client server database model.

This is true for research data as well. Currently, a lot of research data are underutilized in fear of data tampering and data abuse. The more sensitive data a database contains, the more difficult for researchers to share. In extreme cases, researchers are required to be physically present in the site in which a database server is located. In less extreme cases, data are provided only by CD roms, which many PCs are no longer equipped to read. Although all these are necessary precautions if there is no other ways to share research data, they severely limits the sharing of valuable data. Blockchain is expected to alleviate this problem.

2.2 Centralized or Decentralized Data Ownership

We need to first define what centralized data ownership or decentralized data ownership mean. Most data are centrally managed. Even before the advent of the internet, governments were responsible to issue birth certificates, register families, record ownership of real estates and so on. Based on these government records or issued documents, you can open a bank account, purchase an airline ticket, rent an apartment. In due courses, those data are stored and managed by companies offering services to you. It is easy to see the necessity of centrally management data because, as a citizen, you need to have someone to record your place in the social machine. With the internet coming to play, this centrally managed data became more interconnected but the overall structure stayed the same. The current internet service model is mainly the client server model where one server or a cloud server will manage data for many client devices, and the client is dependent on the server to store and manage data. In such a model, a client is provided an ID and a password, so the client can access the server and exchange data with it. All the interaction data is stored together

[2] For an analysis on the peril of such data monopoly in a broader context, see Yano (2020), Pu and Yano (2020) and Yano et al. (2020).

with other data provided by the client in the server. Normally the client cannot see what operations are done to the data it stores in the server. Hence, in this model, the server that is centralized has the ownership of the data. If data needed to be shared with another client or another server, perhaps in a different system, the server that stores the data will have to do the work, not the client.

In a decentralized data ownership model, data is not being controlled by the server; rather, it is stored and managed by the client. How is this possible? There are different ways to achieve this. Data can be stored locally in the client's device rather than the server, and when data sharing is needed the owner of the data and the device will give permission to share that data, similar to Apple's proposed method. On the other hand, the data can still be stored in the server, but encrypted with a key only the owner of the data has. When others request that data, the owner of the data can re-encrypt the data with the key the requesting party provides. An individual or the owner of the data can have control of with whom to share the data in a secure way.

We must note that there is no pure centralized data ownership or pure decentralized data ownership. Any data ownership model rest somewhere in between the centralized and decentralized. However, the proliferation of client server models in the internet platform architecture has ensured that most systems manage data closer to the centralized model rather than decentralized model. The growing needs of personal data collected by internet giants also feeds and favours the centralized model as platforms can easily use data to scale its business, which brings in more users/client. Then it can collect more data and grow bigger and investors will invest more money to build an even bigger platform to store and collect data. The advent of blockchain technology has shown a different option for data management, with the decentralized data ownership model. This new model may even bring change to the business models of internet business.

2.3 Bitcoin, the First Blockchain Application

Blockchain technology was first introduced to the public by the bitcoin whitepaper.[3] Although in the paper there was no mention of the word "blockchain", only references to "blocks" and "chain", the decentralized data ownership model was very clear. Bitcoin's purpose was to build a global ledger that is not stored in a single server but maintained with the consensus of tens of thousands of servers. Without a centralized data management entity such as a bank, ownership of data can be managed individually and that ownership can be transferred between users. Bitcoin, the first successful use case of blockchain, demonstrates the promise of the decentralized data ownership model. Bitcoin became a digital currency that does not need banks to manage the storing and transfer of money. In fact, bitcoin does not need any intermediary for one to send or receive money from one another.

[3] See Omote and Yano (2020) for technical details of blockchain-bitcoin technology.

You might ask what money has to do with data. If you think about your money saved in a bank, when you transfer your money to another person in the same bank, the actual cash does not move; rather the data on your account is updated by the bank. In essence, money saved in a bank is just a piece of data managed by the bank, and is a form of centralized data ownership. In the case of the bitcoin, because there is no bank to manage your data, individuals have ownership of their data.[4] To achieve decentralized data ownership and at the same time ensure secure transfer of money, the bitcoin system has to ensure several key functions. First, the system has to know you own your account every time you send an instruction to send money. With a centralized system the bank will issue you an ID and password to make sure when you are sending online money transfer instructions, you are the account owner. However, in a decentralized system like bitcoin that utilizes blockchain, you generate your own ID and password using an encryption technology called public private key encryption. When you send money to another account, money or balance will be deducted from your account and added to another account and this process is not reversible. To make the transfer non reversible or immutable, blockchain protocol has all the servers on the network to reach consensus on the data of the transfer of money and keep the same copy in all the servers. To reverse the transaction, hackers have to hack over half of the servers in the blockchain network, which is nearly impossible considering there are more than 10,000 servers running bitcoin full node. Bitcoin has demonstrated blockchain technology can make a decentralized or individual data ownership model possible. It is important to mention that since the start of bitcoin on January 3, 2009, the system has never been successfully hacked or been taken down for maintenance. A rather incredible feat for any online system.

3 UniCask: A Use Case of Blockchain Technology

The use of blockchain technology is not limited to support crypto currencies like bitcoin. Blockchain can set the ownership of even a physical material and support a digital marketplace in which the physical material can be traded among participants. The existence of such a technology implies that research can be shared among researcher on a blockchain.

This is made possible because a blockchain can provide a secure internet platform on which any software program can run and execute predetermined arrangements. Ethereum is the first blockchain that offers such a capability.[5] Simply put, Ethereum is like an operating software (like Windows and iOS) on the internet of which the security is endowed in a decentralized manner. Just like some computer games on the internet, Ethereum lets an algorism designer write a program on Ethereum blockchain (which we call a "use case" here) and incorporate virtual money into that use case. By using this function, a blockchain engineer can write a specific use case for a particular

[4] See Yano (2020) for an explanation why decentralized data may have monetary value.

[5] For more explanation on Ethereum and its applications, see Metcalfe (2020) and Dai (2020).

group of researchers who can securely store and share with other researchers, their valuable research data on the use case and even trade their research data for a price among themselves.

In order for researchers to share research data, a blockchain must have several crucial features. Before studying those features, it may be useful to examine a use case that makes it possible to digitalize a physical commodity or, more specifically, whiskey casks and put its ownership on a blockchain marketplace. From the economic viewpoint, a whiskey cask is a very simple product. Because of this simplicity, a comparison of its economic features with research data lets us highlight what might be necessary to design a blockchain to sharing research data, which we will discuss at the end of this section.

3.1 Proving Ownership on Physical Good Over Internet

Many of the use cases for blockchain are indeed arising from financial industry where data itself is money and hence easier for a decentralized data ownership to show its value. Crypto currency, decentralized finance are the thriving examples. On the other hand, decentralized data ownership model is not limited to finance and many industry sectors are utilizing blockchain to build new business models to utilize individual data ownership. One such interesting use case is UniCask. UniCask links physical casks of whiskies to data on the blockchain to register the ownership of the casks. This model is not only applicable to whiskies but to most physical assets if applied correctly.

Most whiskies we know are packaged in glass bottle form. They are sold to bars, supermarkets, and liquor stores etc. However, what most people don't know is that for whisky collectors, bottled whiskies are not good enough because once the whisky is bottled, it stops aging, a term used to describe whisky stored in a wooden cask and in contact with the wood. Aging is important for whisky because the longer it ages, the taste becomes smoother and it is also a good indicator of how rare and expensive the whisky is. However, whisky in the cask form is not sold in stores. It is not easy to buy whisky in the cask form unless you have good connections in the whisky industry and are in the inner circle of the trade. To buy a cask of whisky usually means storing the aging whisky in the distiller's warehouse for years until the time is ready for you to drink it or sell it to someone.

While the cask is in the warehouse of the distiller, only you and the distiller know about your ownership of that particular whisky cask. Your proof of ownership of the cask is stored and managed by the distiller. If you need to prove to someone you own the whisky cask, you have to have to take that person together with you to go to the distiller to show your cask and get the distiller to confirm your ownership. Of course, the distiller can print a proof or ownership for you or you can even make a photocopy of your contract with the distiller. However, it is difficult to prove the authenticity of such documents and even if the other party can trust that any document you produce can only prove your ownership up and until the date of the document. It is difficult to prove your "current" ownership if such data is managed centrally.

One way to solve this issue is to use the blockchain technology and create a decentralized global registration of casks. UniCask did just that, and created a standard for distillers to issue tokens or ownership certificates for its casks to the owner. These tokens are issued on Ethereum blockchain. Unlike the bitcoin tokens which we call fungible tokens where every token is virtually the same and inter changeable, the UniCask ownership certificate tokens are non-fungible tokens that each token carries a unique cask id to avoid duplicate tokens. The ownership certificate token is stored in the blockchain account created by the owner. If you are the owner and want to sell your cask, then before you negotiating with your potential buyer, the buy will ask you for the proof of ownership of the cask. First you can send the link to show this cask ownership certificate is in the account. Then using your account private key to make a digital signature, you can digitally show that you have control of the account and hence own the cask. The high security level of decentralized data ownership mode also ensures your transaction much more resistant to scamming and hacking. UniCask allows whisky collectors easily and more securely trade casks over the internet. It also takes away the hassles of the distiller to centrally record and manage cask ownership.

3.2 Blockchain for Researchers to Share Their Data

A whiskey cask is a very simple product from the economic viewpoint. Until it is opened, its value for consumers does not materialize.

Once it is opened, it will become a totally different object, i.e., a large empty container and a large quantity of whiskey usually in many bottles. So long as a cask is not opened, its physical quality/quantity will not change, no matter how many times a cask is traded and changes its owner. The value of a cask will be anchored by the value of whiskey at the time at which the cask is opened. Thus, the digital ownership of a cask cannot become a target for speculation, unlike a blockchain currency. Digitalization may be a perfect way to own a cask because it permits a change of ownership without physically moving it; moving casks physically might harm the stored whiskey. The transaction of digital ownership for cask makes it possible for potential owners of casks to share storing costs. The transaction of a cask does not reduce the physical quantity/quality of whiskey.

These features of whiskey casks are shared by research data. Once data becomes publically known, it loses its proprietary value. So long as data is kept secret, its physical quality/quantity will not change. The digital ownership of data cannot become a target for speculation. Digitalization may be a perfect way to own research data because it permits a change of ownership without physically moving it. Physically moving data from one server to another involves a large risk by an accident that may occur in transportation. The transaction of digital ownership for research data makes it possible for potential owners of data to share storing costs. The transaction of data does not reduce the physical quantity/quality of research data.

An important difference between research data and whiskey casks is that sharing of data involves handing over data from the hands of an original owner to a user. For these reasons, a blockchain for research data sharing needs to be capable of delivering data securely to the data user. This implies that a blockchain has to provide a virtual environment on the side of users to securely hold data. If data would spill out of users' hands, the blockchain would lose its value.

For the owner of a whiskey cask, it does not matter who buys his cask. In some cases of data transactions, it may be desirable to limit users of research data to a certain group. This is particularly so if data involves national security so that the authority desires to keep the data within its country. It is also possible that for certain industrial data, a certain group of companies desire to share data only within themselves.

A related issue is that once researchers acquire data, they will use it for their research. It is possible that data users wish to keep it secret that they plan to use particular data, which might reveal their research ideas to competitors; researchers rarely desire to reveal their research agenda before research is completed.

Whiskey casks have large asset values. Thus, data security should be of the fore most importance for potential participants of a blockchain marketplace for casks. In contrast, many types of data do not have such an asset value. Instead, researchers may simply seek for convenience of secure data sharing, which a blockchain makes possible. Sometimes, research data may lose immediate research value after a certain period, but continues to be potentially useful for future research, which is unknown. In many cases, the production of research data is funded by a government, which may desire to make data output open for public purposes; it is often the case that government funded research data will be made open to the public after a certain period.

In designing a blockchain for research data sharing, it is important to take these points into account. They are however very partial, and a blockchain designer should design a blockchain that is tailored for specific necessities and requirements for researchers.

4 Individual Taking Control of Personal Data: Research Data Access (RDA)

As is explained in the previous section, physical products like whisky can be owned and traded as data on blockchain, so long as a proper contractual arrangement is made. If so, there is no question that research data can be owned and traded on blockchain. Additional difficulties will arise, however, if researchers are to share their research data with test subjects. If data involves a serious disease like COVID-19, as is discussed in the introduction, extreme care is necessary in data handling. Anecdotal evidence indicate that governmental officials are highly reluctant to handle research data involving sensitive test results, for they are afraid of possible errors associated with data handling; this is not at all a surprise if we think of the Fukuoka incidence discussed in Sect. 1.

In this chapter we are discussing the characteristics of this new system model as opposed to the current centralized model, and the implication of such change. The *Nagahama Study*, a social scientific survey on the life and views of participants to the Nagahama Prospective Genome Cohort for comprehensive human bioscience provided an excellent use case for demonstrating how individuals' personal information can be securely managed by the individual test subject. The system architecture and design for implementing the decentralized data ownership model for this project is analyzed.

4.1 Personal Data

In the previous sections, individual ownership of financial data (money) and physical asset data is discussed. Now let us analyze how you can own your personal data. The definition of personal data varies between different countries and jurisdictions. Because the EU is leading the world in protection of personal data, we will take its interpretation. According to the EU's General Data Protection Regulation[6]:

> "personal data" means any information relating to an identified or identifiable natural person ("data subject"); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person.

Refereeing back to Sect. 1, the data that the Fukuoka prefectural government managed and the data Apple collected from its user and managed are all categorized as personal data. As pointed out, personal data collected on individuals are mostly stored in the central server of the institution that manages the data without the individual's knowledge of how that data is being used. It is doubtful that people on the infected resident list would have given their personal information if they knew staff in the prefectural government would just email a link with access to their personal data to a third party. In the same way, Facebook is worried that if Apple asks its users to give Facebook permission to track them, users will not give such permission. Although centrally managed personal data seem to have many issues, but people did not have much of a choice but to use them. With the development of a decentralized model such as blockchain, we see new options.

[6] Regulation (EU) (2016/679) of the European Parliament and of the Council 2016, p.33.

4.2 Research Personal Data Management

With any new technology, the actual breakthrough needs to have a robust, easy to understand use case to demonstrate its superiority. Past cases such as the steam engine used for locomotive and gunpowder used for guns demonstrate this well. What is a good use case for decentralized management of personal data that can benefit both society and the individual? In the previous chapters of this book, a wide-scale collaboration of natural science and social science is proposed. Centering on the same cohort/panel participant group and connecting data between the two distinct area of science will provide great insight to understand the impact of the COVID-19 outbreak on the social, human, and health aspects of individuals and the community. As the research extends its scope, more research can be expected to build on top of the data collected for this research. The data collected is personal data, which should be kept private for privacy reason. On the other hand, we want to encourage the individual or test subject to also give more research teams permission to use his or her data for social good. To create such a sustainable system for managing research data it needs to satisfy the following requirements.

(1) Individuals or test subjects will be given the right to view their personal data and a history of what research it is being used for.
(2) Personal data of the individuals will be accumulated across research projects but research projects do not store personal data that can identify the individuals.
(3) Data is securely stored and only individuals or institutions with permission can access the data.
(4) Minimizing manual operation and cost of running the system.

With the above requirements in mind, we have designed a system utilizing blockchain technology to be the first of its kind to be used for managing personal information collected for research purpose. The design, building, and operating of this new system itself is a research to validate the implementation of decentralized personal data management in a real-world use case.

4.3 Why Blockchain?

4.3.1 Decentralized ID and Use of Private Key Public Key Encryption

When the centralized data ownership model is compared with the decentralized data ownership model, the first difference is user authentication. In a centralized data ownership model, the central server takes the responsibility of linking data with the ID. When the user inputs ID and password correctly, the server recognizes that the user is logged in and the user account is given access to read the stored data or is able to instruct the server to execute actions such as giving access to another user. When operated properly, the entire process is very smooth and nothing to worry about.

However, what we do know is that this kind of centralized system is always under threat from hackers to exploit its weakness. How is a decentralized system different in user authentication?

A decentralized system does not use the centralized system to authenticate the user; rather the user creates their own ID (public key) and password (private key) using the public key encryption algorithm. Then the user registers the public key on the blockchain. The actual personal data can be stored in a server, but encrypted using the public key of the user. As a result, even if the server is hacked and controlled by a hacker or the data somehow leaked, data decryption needs the user's private key, which is not managed centrally but managed by each user.

In a decentralized system, the whole system is divided into smaller autonomous sub system unit with simple logic. Individuals directly interact with those sub system units; some of them can run directly on the individuals' device instead of a server. Because the sub system unit does not have to take into account of all the states of the user, it is far less complicated and easier to manage. A centralized system, on the other hand, has to take into account all the states of the system, with millions of variables all orchestrated centrally. Thus, a centralized system is a lot more complex than the decentralized system, where the sub systems individually are simpler, and therefore can contain less opportunity for hack to attack.

To put it in a more intuitive perspective, normally commercial software has 20 to 30 bugs or error in the computer program per 1000 line of code. And these bugs become security risks. For example, Windows XP contains about 40 million lines of code; suppose it is about 20 bugs per 1000 lines for Window XP then there should be about 800,000 bugs contained in the software (WIRED 2004). All of Google's services together take two billion lines of code. With that many possible security risks contained in the software, you may now understand why systems gets hacked; it is almost unavoidable. Bitcoin in comparison only took 14,000 lines of code, which means a lot fewer possible bugs.

Because creating a secure centrally managed research data management system is complex and difficult, manual processes and organizations are put in place to protect and anonymize personal data. However, as shown in the example of the Fukuoka government case, human errors are inevitable and such manual operation cost adds heavier burden to the continuing operation of the full system.

4.3.2 Storing Hash Values to Public Chain to Prevent Tempering of Data

You may ask what if the hacker gains access to the server and replaces the data with fake data? How is a decentralized system going to prevent it? After all, anyone can find the user's public key on blockchain and use that to encrypt arbitrary data to replace the original encrypted personal data. To counter that, a hash value or digital fingerprint of the original unencrypted personal data is written into blockchain. Data written into blockchain is very difficult, if not impossible, to hack, as attested by the track record of bitcoin. Data written into blockchain is very temper-resistant. It is a lot easier to hack a central server to replace a file compared to replacing data in the blockchain. Anyone given the right to decrypt personal data can calculate the hash value of the data and compare it against the hash value stored in the blockchain. If the two hash values are the same, the authenticity of the file is proved; otherwise, we suspect the stored encrypted personal data file is not the original and must have been tampered with.

4.4 System Architecture

4.4.1 Overall System Architecture

The system built for this research project, called "RDA" (research data access) combines blockchain and cloud servers as shown in Fig. 1. RDA is divided into three parts, with data storage divided into two layers: the application server layer and the blockchain and recika middleware layer. By storing inspection data in both the application server (cloud) and the blockchain layer, instead of storing all antibody test data in both the application server and the blockchain layer, test result data can be stored more securely and uploaded and retrieved with higher processing speed. The test result data for this project is very similar to medical data of patients stored in hospitals. Various projects have examined mechanisms to manage medical personal data using cloud services. However, in the medical data management field in Japan,

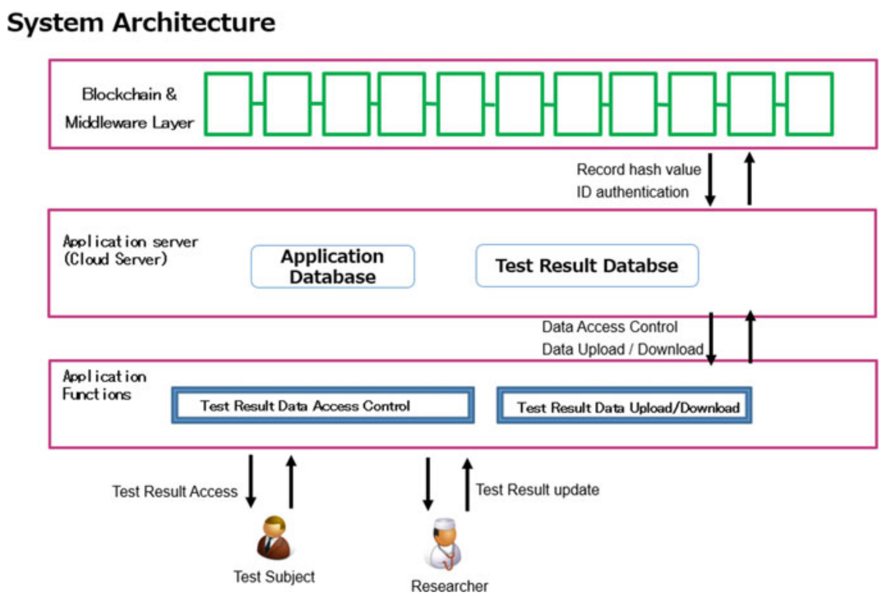

Fig. 1 Overall system architecture

people have strong safety concerns to store sensitive medical data in cloud servers. For this reason, the security of cloud services has to be strengthened through decentralized ID and encryption technology by using blockchain. By providing double security utilizing blockchain and adding a new authentication layer, we can further improve the security level of cloud servers and promote its use in the medical field. We chose to use the Ethereum chain for this project. We shall explain, with emphasis on the scalability and limitation of the blockchain, why this system architecture is most suitable for managing antibody test data.

4.4.2 Blockchain: The Challenge of Writing Data Using Ethereum

Ethereum, like bitcoin is one of the world's most widely used blockchain. Unlike Bitcoin, Ethereum can write not only transaction data such as money transfer to the blockchain, but also can write program codes called "smart contracts" to the blockchain. Ethereum public blockchain is well known to have high resistance to data tampering and hacking because of its highly decentralized structure, characterized by the absence of a centralized controlling entity. On the other hand, there is a limit to the amount of data that can be processed, and the amount of data that can be written to the Ethereum blockchain worldwide is only 20 kilobytes of data for every 15 s, compared to a normal hard disk that can write 80–160 megabytes of data per second. You can imagine Ethereum as a very slow but secure computer that every device can connect to and interact with but without the risk of being hacked.

The personal data in this project can be anything from images, videos, and text data which can add up easily to several megabytes. Theoretically it is possible to write that amount of data directly to the blockchain, but the speed mentioned above and also the associated costs that we have to pay to the blockchain for the transaction makes it difficult if not impossible to use in practice. To overcome this challenge, instead of writing the personal data itself to the blockchain, we devised a method of first writing the data to a database on a cloud server, and then writing the hash value of the data to the blockchain. The hash value is a fixed length value obtained from the original data by a certain calculation procedure (hash function), and the hash function used in this project uses the SHA-256 hash algorithm, which means that the data after being hashed is always 32 bytes. What this means is that instead of writing one megabyte of data to the blockchain, a 32-byte hash value of that one megabyte data is written to the blockchain, and this method makes it possible to increase the processing speed of the blockchain. At the same time, since the hash value will be completely different if the original data changes by even a single bit, the smallest unit of data in a computer, data tampering is easily detected. In addition, given the "transparency" of blockchain, even if the original data is written directly to the blockchain and encrypted, there is a possibility that it will be deciphered in the future. Therefore, writing only the hash value, not the original data, to the blockchain is the better choice for this project.

4.4.3 Description of the Parts of the System Architecture

In this section, we shall explain the application database, test result database, and test result data access control in more detail.

Application database: The application database is a database that stores the necessary data to run the application. For example, it stores data such as application configuration values, chat logs, and system access logs. Some of the data stored in the application database (for example, chat logs and system access logs) can be periodically processed to have hash values calculated and written to the blockchain to prevent data tampering. If a hacker gains control of the application database, and tampers with the stored data, such changes can be easily detected by a third party that later retrieves the altered data.

Test result database: As mentioned earlier, the test result data, which is personal data, is stored in the test result database in the cloud server because it is not possible to write all the test result data to the blockchain. The data are not stored in the original file format, but encrypted so it can only be decrypted with the test subject's private key. Since each test subject's test result data is encrypted individually, even if the database is hacked, it is very difficult for hackers to decrypt all the data. Thus, this decentralized form of data storage/encryption is more secure. It is far less cost effective to hack decentralized encrypted data than a centralized server with centralized encrypted data. In fact, most databases managed centrally have this risk. Once the walls of the security measures are broken and hackers get control of the server, data is easily stolen.

Test result data access control: One of the important features of this project is the blockchain-based access control, which was implemented to add double security by combining it with the cloud access control (Fig. 2).

First, in order for a test subject to successfully access his or her test data, the test subject must create a decentralized ID and password pair, or public key and private key pair. The test subject will have the test administered and receive an ID to identify that particular test. Then the test subject submits his or her own decentralized ID and test ID to link the two. On the researcher side, after the test is administered, if the test ID is linked with a decentralized ID, then the test data is encrypted in such a way that it can only be decrypted with the test subject's private key. This encrypted data then is uploaded to the cloud. In order for the test subject to access his or her own test data, the test subject must have the private key to unlock the encrypted data in addition to the ID and password to access the cloud database. This system scheme provides double layers of security because even if the encrypted data in the test result database is stolen, no one can read the original data or identify who owns that data.

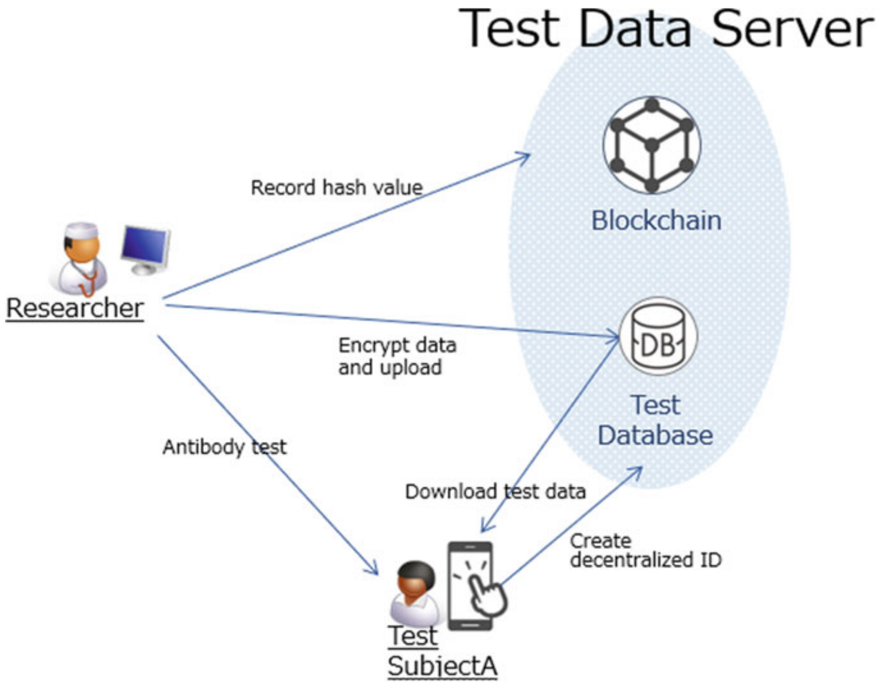

Fig. 2 Blockchain-based access control for antibody test data

5 Looking Forward

5.1 Challenges for the Decentralized Ownership Model

We have talked about the potential of using blockchain technology for a decentralized data ownership model and the many benefits it offers for storing personal data securely. There are several challenges to implement the technology in an actual use case. First is the challenge of not forgetting the password or private key. Internet users are very comfortable with a centralized server managing their ID and password and if either or both are forgotten, ID and password can be reissued. However, with a pure decentralized system, the private key is the only thing that can identify a person; thus losing the private key is equal to losing that data. Also the cost of recording all transaction data in the public blockchain is expensive. At the time of writing this chapter, the cost of writing a single transaction into Ethereum is around 30 USD, too expensive for most use cases.

The solution to both challenges lies in how to keep the balance between centralization and decentralization. A pure centralized system or a pure decentralized system only exist as concepts, but in reality most systems fall in between those idealized concepts. For the ID and password issue, we can make only a portion of data management decentralized, but have a central entity to manage personal data offline. For individuals who forget their private key, a more analog process of reclaiming a new set of public keys and private keys can be implemented. The solution may not be elegant but can still minimize the risk of leaking data by utilizing blockchain technology. The approach to lower the cost of using Ethereum public blockchain is similar too. There are different types of blockchain with varying degrees of decentralization. A public blockchain is considered the most decentralized but also most costly to use. Therefore, by sorting out the types of transactions and use consortium blockchain and private blockchain for recording of most transactions and only record hash value of the private blockchain or consortium blockchain chain periodically to ensure immutability can be one solution that gives up some decentralization for cost. These solutions are being tested in this research project and we shall analyze the results in the future.

5.2 Data Sharing Between Research Teams

Further in our research, we would like to see how accumulated test data can be shared between different research teams to add value to scientific research in general. In order for another research team to access the test subject's data, a prior permission needs to be obtained from the test subject. This permission is normally done on paper, but the existence of that paper permission itself is personal data and can identify the test subject. A better way of digitally obtaining the permission and also analyzing the data is required. The decentralized ID created by the test subject may be a good way for the test subject to give permission to use his or her data anonymously. The test subject can use its private key in the form of a "digital signature" to give permission to access data.

For a decentralized data ownership model to truly function, we have to change the old model of passing the data to a third-party researcher to analyze the data. Instead, a better solution might be that the researcher provides the algorithm to analyze the data. Then in a safe computation environment, the data from the test subject is temporarily decrypted and analyzed with the algorithm provided by the researcher. The analysis result will be passed to the research but the input personal data is kept secret. To make this happen, technology advancement on zero knowledge proof, homomorphic encryption, secure hardware computation, and others are need. Although it may take some time before all these technologies mature, hopes are high that, in the near future, decentralized data ownership and data sharing are going to change the way we manage data.

References

Dai C (2020) DEX: A DApp for the Decentralized Marketplace. In: Yano M et al (eds) Blockchain and Crypto Currency. Springer, Tokyo, pp 95–106

Guardian (2019) Revealed: 50 million Facebook profiles harvested for Cambridge Analytica in major data breach. The Guardian. 17 March 2019. www.theguardian.com/news/2018/mar/17/cambridge-analytica-facebook-influence-us-election

Mainichi Japan (2021) Personal info on 9500 coronavirus patients possibly leaked in southwest Japan. The Mainichi. 8 Jan 2021 https://mainichi.jp/english/articles/20210108/p2a/00m/0na/006000c

Metcalfe W (2020) Ethereum, Smart Contracts, DApps. In: Yano et al. (ed) Blockchain and Crypto Currency, Chapter 5. Springer, 77–94

Omote K, Yano M (2020) Bitcoin and blockchain technology. In: Yano M et al (eds) Blockchain and Crypto Currency. Springer, Tokyo, pp 129–136

Pu S (2020) Industrial applications of blockchain to IoT data. In: Yano M et al (eds) Blockchain and Crypto Currency. Springer, Tokyo, pp 41–58

Pu S, Yano M (2020) Market quality approach to IoT data on blockchain big data. In: Yano M et al (eds) Blockchain and Crypto Currency. Springer, Tokyo, pp 21–40

Regulation (EU) 2016/679 of the European Parliament and of the Council 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation). Official Journal of the European Union

WIRED (2004) Linux: Fewer Bugs Than Rivals. WIRED. 14 Dec 2004. www.wired.com/2004/12/linux-fewer-bugs-than-rivals/

Yano M (2020) Theory of Money: From Ancient Japanese Copper Coins to Virtual Currencies. In: Yano M et al (eds) Blockchain and Crypto Currency. Springer, Tokyo, pp 59–76

Yano M, Dai C, Masuda K, Kishimoto Y (2020) Creation of Blockchain and a New Ecosystem. In: Yano M et al (eds) Blockchain and Crypto Currency. Springer, Tokyo, pp 1–20

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Makoto Yano is Chairman of the Research Institute of Economy, Trade and Industry (RIETI); he is also a specially appointed professor at Kyoto University and Sophia University. He is an internationally known researcher who has made a number of substantial contributions in international trade, and especially on economic dynamics. In a series of recent research, Yano proposes market quality theory, addressing various problems in modern economies, including the financial market crisis since 2008 and the recent nuclear accidents in Japan, from the point of view

of market quality. Concerning quality of competition, quality of information, and quality of products, market quality is defined as an index jointly determined by the efficiency of an allocation and the fairness of the prices that are achieved in a market. An influence of his theory can be seen in Krishnendu Dastidar's book, Oligopoly, Auctions and Market Quality (2017), included in the same Springer book series as the present volume. Yano received a BA in economics from the University of Tokyo in 1971 and a PhD in economics from the University of Rochester in 1981.

Part III
Socio-Life Science on Public Health and Behavioural Change

Chapter 11
Potential Transmission of Dengue Virus in Japan

Akiyoshi Senda, Anavaj Sakuntabhai, Fumihiko Matsuda, and Richard Paul

Abstract The global burden of dengue is increasing at an alarming rate and increased international travel will lead to constant importation of dengue virus into non-endemic areas. The potential for dengue epidemics in such countries during seasons with permissive temperatures has already been underlined by epidemics in Japan and Madeira. While improved surveillance can help identify clinical cases of dengue, differentiating between imported and autochthonous cases remains problematical. Implementation of a threshold criterion can help in identifying aberrant incidences of dengue. This threshold approach was applied to dengue cases reported in the Japanese surveillance system from 2011–2019. Several aberrant incidences occurring during consecutive weeks were detected, one of which was concomitant to the Yoyogi Park Tokyo epidemic but in another area, Kanagawa, and another above threshold week was coincidental with a symptomatic case of a German traveller. This indicates autochthonous transmission. Despite the occurrence of several alert periods, however, on no occasion did the spread of dengue progress into a full epidemic as was seen in Yoyogi. It thus seems likely that Yoyogi Park was a particular event and that stochastic die-out of viruses is occurring frequently without progression, perhaps reflecting the negative impact of societal infra-structure on dengue transmission despite permissive temperatures. Implementation of a dengue epidemic threshold as used for seasonal influenza may provide a basis for future seroprevalence studies to assess the true prevalence of dengue in light of the high frequency of subclinical, asymptomatic infections.

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Keywords Dengue · Autochthonous and imported cases · Epidemic alert · Critical community size · Japan

1 Introduction

Dengue is a mosquito-borne viral disease with a major international public health concern as a consequence of urbanization, globalization, and global warming (Gubler and Kuno 1997; Halstead 2007; Lambrechts et al. 2010; WHO 2015). Dengue outbreaks have become more frequent in recent years. More than 3.5 billion people are at risk of dengue virus (DENV) infection, and it has recently been estimated that there are 390 million DENV infections every year, of which up to three-quarters are estimated to be subclinical, resulting in insufficient discomfort for clinical consultation (Bhatt et al. 2013; Grange et al. 2014). However, infection can lead to dengue haemorrhagic fever (DHF) and dengue shock syndrome leading to an estimated 20,000 deaths annually. Over the past few decades, the number of countries affected worldwide and the frequency of epidemics have increased significantly (WHO 2015). This prolific increase has been associated with increased global trade and travel, as well as societal changes such as population growth and increasing urbanization, particularly in tropical cities with poor waste and water management. This leads to the proliferation of the major mosquito species that transmit DENV, *Aedes aegypti* and *Ae. albopictus* (Gubler 2002). *Aedes aegypti* is restricted to the tropics and subtropics and is well adapted to the peridomestic environment. *Aedes albopictus*, by contrast, spread from southeast Asia and has successfully invaded temperate regions such as southern Europe and Japan and found in more sub-urban or rural areas, and in outdoor habitats, such as gardens, parks, or forests. In Japan, *Ae. albopictus* is the main vector, although larvae and pupae of *Ae. aegypti* have been intermittently detected at international airports in Japan since 2012 (Sukehiro et al. 2013).

Rising temperatures associated with global climate change are enabling the spread and establishment of many disease vector species and will influence the capacity of mosquito populations to transmit arthropod-borne viruses such as DENV. Warming can generate optimal temperatures for decreasing the extrinsic incubation period of viral development within the mosquito and mosquito survival, growth, and biting rates (Hales et al. 2002; Misslin et al. 2016; Quam et al. 2016; Thai and Anders 2011). International travel will ensure importation of virus into non-endemic countries from regions endemic for dengue (Chen and Wilson 2008) and the increased global burden of dengue will have knock-on effects in such non-endemic countries. The potential threat of DENV invasion into naïve areas is illustrated by cases of autochthonous dengue intermittently occurring in France and the US over the past decade (Effler et al. 2005; La Ruche et al. 2010; Murray et al. 2013) and both Madeira, Portugal and Tokyo, Japan have recently experienced unprecedented epidemics (Alves et al. 2013; Kutsuna et al. 2015; Seki et al. 2015). In so far as the majority of DENV infections are subclinical and infected individuals can infect mosquitoes prior to expressing symptoms, or even if experiencing no clinical symptoms (Duong et al. 2015), repeated "silent" DENV invasion is likely to be increasingly frequent.

Within this context we examine the case of Japan, which had an unprecedented autochthonous dengue 1 epidemic in Tokyo in 2014, and which is experiencing an ever-increasing number of dengue cases every year, thereby providing an increasing opportunity for new epidemics. Analysing dengue case surveillance data over the last ten years and for the specific case of the Yoyogi Park, Tokyo epidemic, we assess whether (1) there were particular prefectures with constant dengue cases, (2) there were incidences (other than the Yoyogi Park epidemic) when the number of dengue cases exceeded that expected due to importation and whether these incidences represented potential foci of epidemics. Finally, we analyze the Yoyogi epidemic, discuss whether it was an unfortunate rare event, the probability of a repeat epidemic in the near future and the value of establishing a threshold for dengue alert.

2 Materials and Methods

2.1 Surveillance System and Case Definition of Dengue Fever

Since 1999, dengue has been one of the notifiable diseases under surveillance across Japan. The case definition of dengue fever requires suspicious clinical symptoms (fever, myalgia, arthralgia, retro-orbital pain, rash, thrombocytopenia, and leukopenia) and laboratory confirmation (virus isolation, RT-PCR, detection of NS1 antigen or anti-dengue IgM antibodies, hemagglutination inhibition test or neutralization test) (Ministry of Health, Labour and Welfare 2011). Among these diagnostics, the rapid diagnostic test (NS1 ELISA test) has been covered by health insurance for the hospitalized cases after the 2014 epidemic.

In the surveillance system (Fig. 1), physicians report clinically suspect dengue cases immediately to the health centre via fax with demographic, clinical, exposure, and travel history information (Taniguchi et al. 2008) The public health centre is the primary level public health institution (PHI) established in all prefectures and many government ordinance cities. The health centres immediately register the reported cases in the national electronic database and the case report is validated by the regional infectious disease surveillance centre (IDSC) or the regional health department as a substitute. The confirmed data becomes available throughout governmental institutions and other institutions related to public health via the database. The central institution of this surveillance is the National IDSC. Regional IDSC serves the same role at the regional level (Ministry of Health, Labour and Welfare 2018). It takes approximately two days for a case report to be transmitted from a doctor to the national IDSC. If there are no dengue diagnostics available in the hospital, the doctor submits the specimen to the prefectural PHI or National Institute of Infectious Diseases to test the specimen.

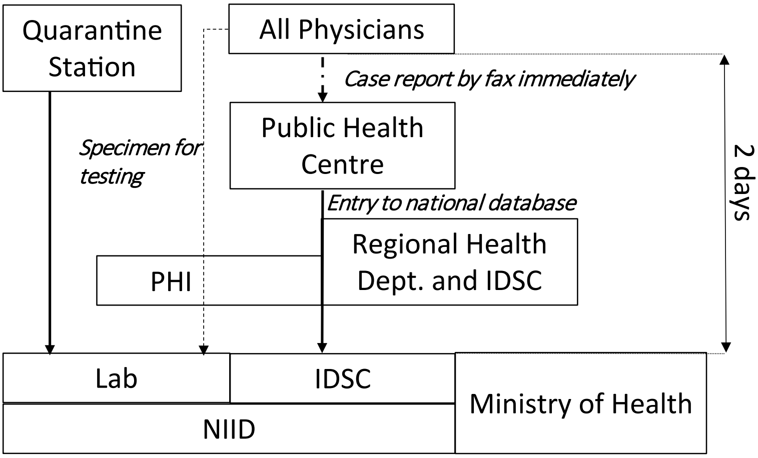

Fig. 1 Surveillance system of dengue in Japan

Key: NIID: National Institute of Infectious Diseases, IDSC: infectious disease surveillance centre under the institute, PHI: public health institutes.

2.2 *Autochthonous Case Definition and Epidemic Response*

The definition of an imported case is infection with travel to a dengue-infected area within two weeks prior to onset of symptoms and an autochthonous dengue case is otherwise (Tuberculosis and Infectious Disease Control Division, Health Service Bureau, Ministry of Health, Labour and Welfare 2016). After an autochthonous case is reported to the nearby health centre by the doctor, the health centre questions not only the patient but also the companions and the cohabitants about their activities and experience of mosquito bites from 14 days prior to onset of symptoms, in order to estimate the place of infection to implement active surveillance and intervention. On receiving the case report and the estimated place of infection, the regional municipalities implement insecticide treatment in the locality, with mosquito abundance measured prior to and after treatment; insecticide treatment may be repeated depending on the efficacy of the first treatment. In addition, environmental hygiene measures are recommended to the local population, as well use of insect repellents and community-based source reduction.

2.3 Dengue Data Source

All of the dengue cases diagnosed by doctors in Japan are registered in the database of surveillance system in Japan, which is published weekly at the website of Infectious Disease Weekly Report (IDWR), the Japanese Ministry of Health, Labour and Welfare surveillance system (National Institute of Infectious Diseases 2021b: www.nih.go.jp/niid/ja/idwr.html). The data are updated in the annual report of IDWR, which is available from 1999 to 2019 (National Institute of Infectious Diseases 2021a: www.niid.go.jp/niid/ja/allarticles/surveillance/2270-idwr/nenpou/10115-idwr-nenpo2019.html). With this data we describe the annual occurrence of dengue. In addition, we then calculate the critical community size (CCS). This is generally used as a broad indicator of the population size necessary for a pathogen to persist in the face of immunity and stochastic die-out (Teissier et al. 2020). That is, if the population size estimated to be necessary to maintain DENV permanently exceeds that of any prefecture, then the virus must be continually imported. The ambient temperature in Japan is suitable (>15 °C) for viral dissemination and spread by *Ae. albopictus* mosquitoes from May until October. Thus, we divided the annual data into two time periods, November–April and May–October, denoted hereafter cold and warm seasons. To estimate the CCS, the number of dengue-free four-week periods per year was plotted against population size and compared in cold and warm seasons (Tokyo epidemic autochthonous cases were removed prior to analyses). Population data were taken from the national census in 2015 (Statistics Bureau, Ministry of Internal Affairs and Communications 2017). A period of four weeks was considered to cover the lifecycle of the virus, including the incubation periods in both man and mosquito (on average respectively six and 15 days at 25 °C (Chan and Johansson 2012). Each year was thus divided into 13 periods by four weeks.

2.4 Background Threshold for Identifying Outliers

The largest metropolitan area, Greater Tokyo area, was then selected for study, encompassing the largest number of dengue cases across the study period. Greater Tokyo area consists of Tokyo, Saitama, Kanagawa, and Chiba. Since this area functions as a commuting zone, the area-based data were calculated from the sum of the case number of member prefectures in each week. To calculate the threshold, the data were extracted from the annual reports from 2005 to the end of 2019, including information on reporting prefectures and estimated place of infection. Tukey's Box Plot method was used to establish the median background weekly incidence of dengue in each study area using the past six years' data. The weekly threshold was defined as rounded-up value of the third quartile plus 1.5 $\times$ the interquartile range of the case numbers from the same week (using the previous six years prior to the year of comparison). A six-year period was chosen since it was the minimal required number of data points for calculating the box plot method (Senda et al. 2018). The six-previous-year weekly thresholds of cases in each prefecture were respectively applied to the weekly reported cases from 2011 to 2019. The Yoyogi Park outbreak was excluded from the analysis. We defined an outlier as a week with more than one case above or equal to the threshold. The "autochthonous epidemic alert" was defined as at least two consecutive weeks of outliers.

2.5 Outlying Events in the Tokyo Epidemic

The Tokyo epidemic in and around Yoyogi Park was analysed separately to assess whether the epidemic was a single event dominated by the cases from Yoyogi Park or whether the cases in neighbouring parks represented a second series of events. Non-linear (Gaussian, double Gaussian) regression models were fitted to the incidence data by day and by place (Yoyogi Park and/or other satellite parks) and the goodness of fit was assessed by the percent of variation explained.

For all statistical analyses and model fitting, we used Genstat version 15 (GenStat for Windows 15th Edition).

3 Results

3.1 Japan Annual and Monthly Incidence

The number of imported cases has been rising steadily over the last decade (Fig. 2), concomitant with the increase in visitors, most especially from Korea, China, Taiwan,

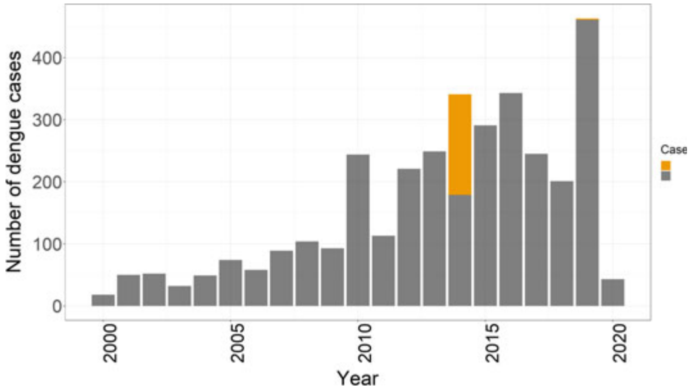

Fig. 2 Annual reported dengue cases reported in the surveillance system (grey imported and yellow known autochthonous)

southeast Asian countries. Until 2015, the number of outbound Japanese travellers exceeded the inbound foreign travellers, of which a third went to dengue endemic countries (including China) (JTB Tourism Research & Consulting Co. 2021). However, since that period the number of incoming visitors has surpassed the outbound travellers. Although the number of tourists visiting Japan does increase marginally during the warm season, outbound Japanese travellers specifically those visiting dengue-endemic countries (for example, the Philippines, Thailand, and Singapore) peak in August. As can be seen in Fig. 3, peak reported cases occur during the summer months, notably August–October, which coincides with the dengue season in endemic countries in Asia.

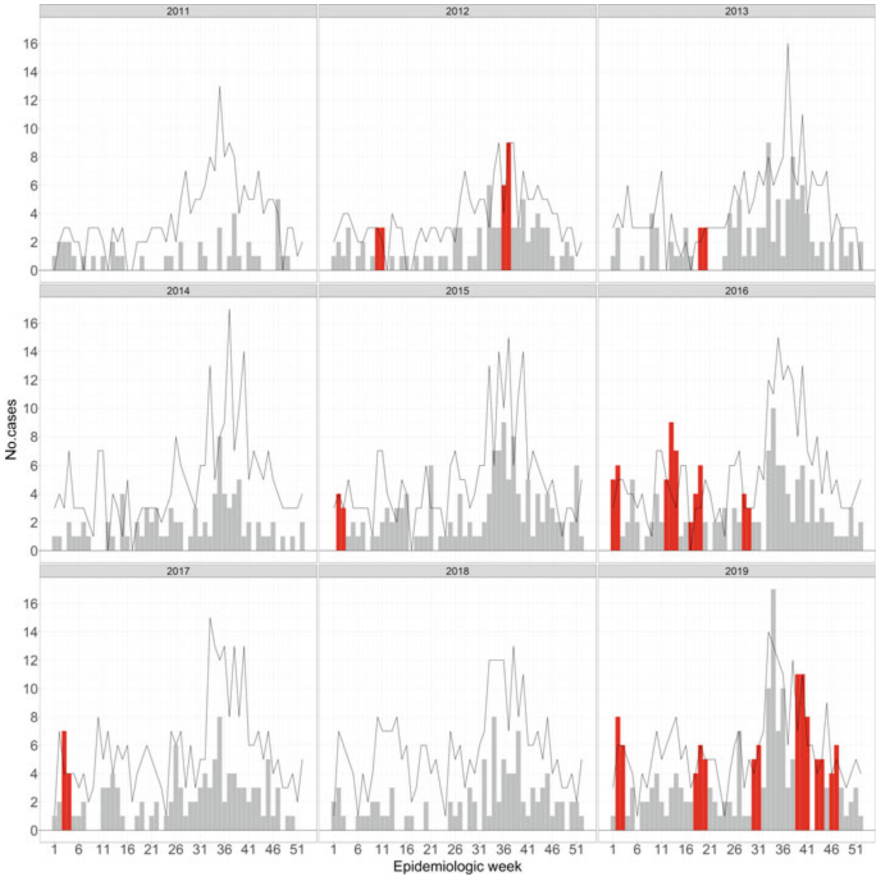

Fig. 3 Detection of conditions warranting an autochthonous dengue case alert (red bars) compared with number of reported dengue cases per week (histogram) and estimated background threshold (black line), by year, Greater Tokyo area, Japan, 2011–2019

3.2 Critical Community Size for Persistent Dengue

As shown in Fig. 4a, b, there is a negative relationship in both seasons between population size of the prefecture and the number of four-week periods during that season with no dengue cases occurring. The cold season relationship clearly reflects the baseline occurrence of imported dengue; during the cold season, the estimated CCS (13.5 million 95% confidence intervals 12.7–14.2 million) is larger than any single prefecture in Japan, indicating that there is no single area having a sufficient frequency of imported cases to maintain permanent, potentially circulating virus; the virus just dies out. However, by contrast, it is notable that the CCS during the warm season is significantly lower (11.8 million 95% confidence intervals 11.1–12.4 million) and the Tokyo prefecture is large enough to maintain transmission (13.5 million). On only four occasions did Tokyo report a dengue-free month during either the warm and cold seasons from 2010 until 2019. While this could be due to higher importation rates in Tokyo during the warm season, DENV is permanently circulating and could generate autochthonous infections. In addition, several smaller prefectures also show some years with dengue every month during the warm season. Overall, there was a three-fold decrease in the probability of having a dengue-free month anywhere in Japan than during the cold season (logistic regression of dengue free month over total months taking into account population size and year: odds ratio = 3.20, 95% confidence intervals 2.69–3.82, $F_{1,904} = 170.4$ $P < 0.001$). Thus, while imported cases are the likely cause of the majority of cases registered, it is not unfeasible that there is potential misdiagnosis of imported for autochthonous cases, where imported cases are defined simply on the basis of recent travel abroad. In the

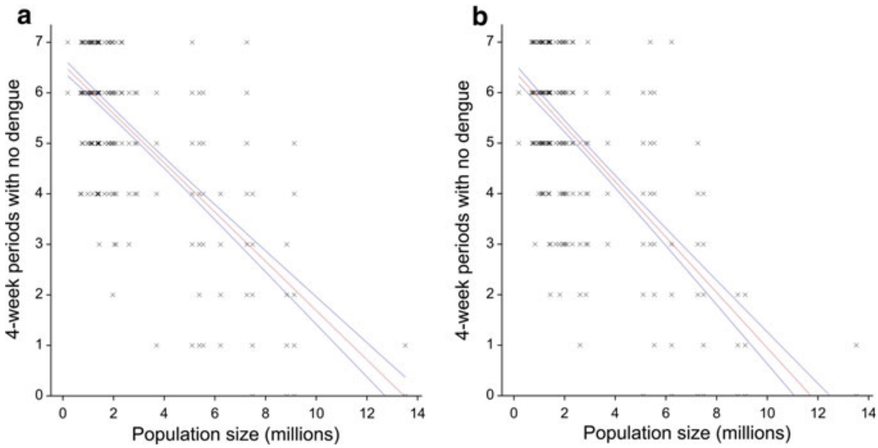

Fig. 4 Critical Community Size of dengue in Japanese cities from 2010 to 2019 in, **a** cold season (November–April) and, **b** warm season (May–October). Shown are the best fit linear regression lines (red) and 95% confidence intervals (blue)

following section we extend a method we previously applied to attempting to identify potential situations of autochthonous transmission (Senda et al. 2018).

3.3 Dengue Incidence and Thresholds

In the Greater Tokyo area, and prefectures within this "commuting zone", the threshold weekly incidence rate was calculated using weekly dengue incidence over the previous six years for each year from 2011 to 2019 using the box-plot method. The observed weekly incidence of dengue cases was then compared to the threshold and outliers were classified as those greater than the threshold by at least one dengue case. Such outlying dengue case weeks were detected in all prefectures and in the aggregated Greater area several times during the nine-year period (Fig. 3). There were several occasions when there were outliers for two consecutive weeks, our definition of an alert, occurring 14 times in the Greater Tokyo area: in 2012 (weeks 10–11 and 36–37), 2013 (weeks 19–20), 2015 (weeks 2–3), in 2016 (weeks 1–2, 12–14, 17–19, 28–29), in 2017 (weeks 3–4), and in 2019 (weeks 2–3, 18–20, 30–31, 39–41, 43–44 and 46–47) (Fig. 3). At the prefectural level, an alert was detected from August 25 to September 7, 2014 in Kanagawa, which coincides with the Tokyo autochthonous epidemic. In addition, nine "alerts" were identified in Tokyo: in 2013 (weeks 32–33), 2016 (weeks 13–14), 2017 (weeks 31–32), and 2019 (weeks 2–3, weeks 18–19, 30–31, 40–41, 43–44, 46–47). The alert in 2013 in Tokyo prefecture was coincidental with the period of visit by a German traveller who was allegedly infected with DENV in Japan (Schmidt-Chanasit et al. 2014). The Tokyo 2016 alerts occurred during (up to week 17) or just after the cold season and were due to an increase in the number of cases imported from Indonesia according to the National IDSC (National Institute of Infectious Diseases 2021c: Notification Trends Among Imported Dengue Cases in Japan). Most alarmingly, we detected five warm season alerts in 2019, three of which occurred almost sequentially during the period from weeks 39–47 (October and November). These alerts occurred just after the peak in imported cases from southeast Asia and elsewhere that occurred in August and September and that diminished steadily in October to reach background levels in November (National Institute of Infectious Diseases 2021c: Notification Trends Among Imported Dengue Cases in Japan). This would raise the suspicion of autochthonous transmission in autumn seeded by imported cases in the summer.

3.4 Tokyo Epidemic Yoyogi Park

The autochthonous 2014 Tokyo epidemic generated 162 confirmed dengue cases, which were spatially clustered around Yoyogi Park. Out of the 162 cases, 131 could be localized to a probable location of infection: namely 110 in Yoyogi Park and 21 distributed among four satellite parks as shown in Fig. 5a. Figure 5a also shows

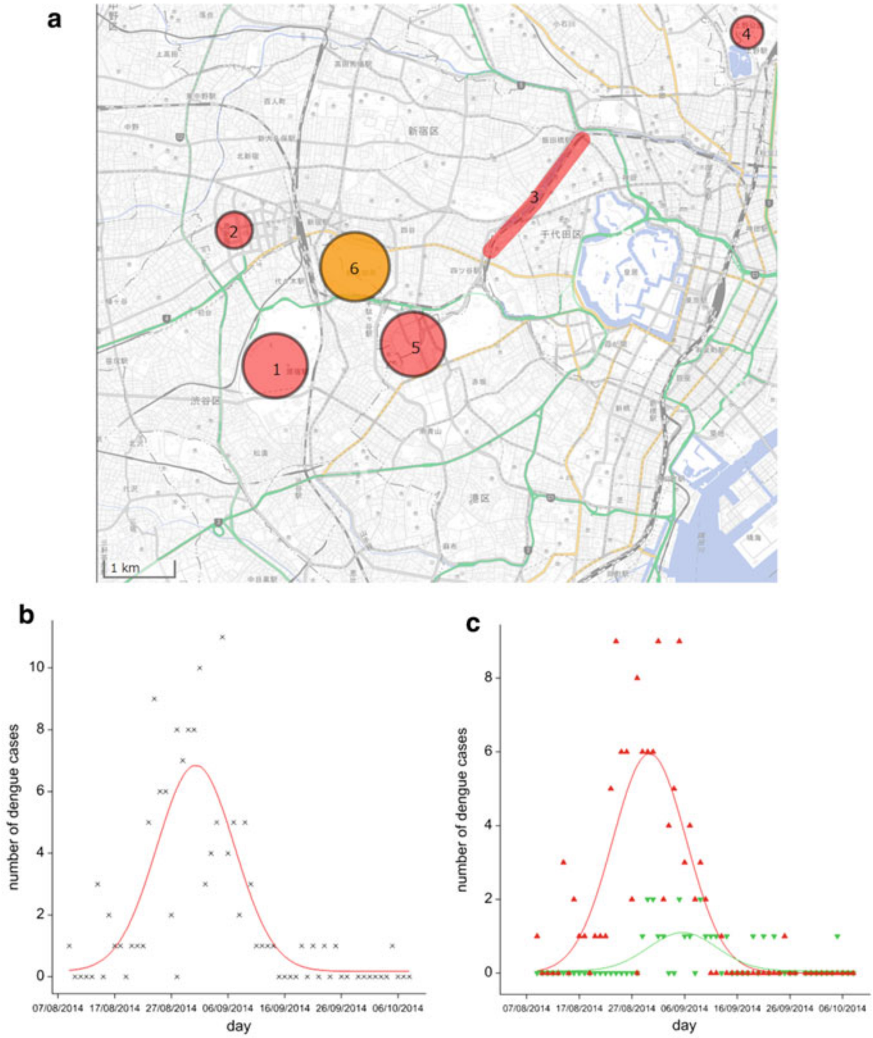

Fig. 5 Yoyogi Park Epidemic. **a** Map of parks with dengue cases: (1) Yoyogi Park, (2) Shinjuku Central Park, (3) Sotobori Park, (4) Ueno Park, (5) Meiji Jingu Gaien Park, ((6) Shinjuku Gyoen Park where only infected mosquitos were detected.) Map edited from electronic topographic map provided by Geospatial Information Authority of Japan to include all parks with cases in Tokyo epidemic (Geospatial Information Authority of Japan 2021); **b** Gaussian fit to all dengue case data by day and **c** Gaussian curve fit treating Yoyogi (red triangles) and satellite (green points) parks separately

Shinjuku Gyoen Park, which although was not associated with any dengue cases, did have DENV-1 positive adult mosquitoes collected from September 11–25 after its closure on the 7th (Seki et al. 2015). To ascertain whether the cases in the satellite parks were simultaneous or subsequent to the Yoyogi cases, we fitted the following non-linear regression models: (1) Gaussian fit to all data from both parks; (2) a Double-Gaussian to all data from both parks; and (3) Gaussian with Yoyogi and satellite parks treated as independent. The double Gaussian curve yielded the poorest fit ($F_{5,55} = 21.4$ $P < 0.001$; 62.9% variation explained). The Gaussian fitted to all data yielded a similar result ($F_{3,57} = 35.4$ $P < 0.001$; 63.2% variation explained) (Fig. 5b). Treating parks as separate entities yielded the best fit ($F_{5,116} = 45.9$ $P < 0.001$; 65.0% variation explained) (Fig. 5c). The epidemics in Yoyogi and the satellite parks are therefore not contiguous, with the seeding event clearly arising in Yoyogi Park and leading to delayed cases in the satellite parks, but which failed to generate a large number of cases in any of the satellite parks.

4 Discussion

In this study we have addressed the potentially increasing invasion probability of dengue into Japan following the wake-up call of the 2014 Tokyo mini-epidemic. The number of dengue cases reported in Japan has been increasing yearly, is concomitant with the increasing human flux between Japan and dengue endemic areas, and related to the population size of the cities within Japan. Tokyo in particular has persistent cases of dengue throughout the warm months of the year and the frequency of anomalously warm spring, summer, and autumn months has been suggested to increase the probability of a second dengue epidemic in Japan at this time (Quam et al. 2016). Japan previously had epidemics in the 1940s, but not until 2014 when there were autochthonous cases reported. However, there have been several reports of travellers contracting dengue while visiting Japan, which suggests that DENV is circulating either as silent infections and/or that allegedly imported cases are indeed autochthonous (Kojima 2015; Nakayama et al. 2016; Schmidt-Chanasit et al. 2014). While acknowledging the persistent “background” rate of likely imported dengue cases, there are clear occasions when there are aberrantly high numbers of cases, supporting a role of autochthonous transmission, but which does not then lead to an epidemic, despite permissive conditions.

The critical population size analysis clearly showed that DENV can be expected to be circulating persistently throughout the warm season in Tokyo, whether from viral importation through returning tourists or visitors, or subsequent autochthonous transmission. Epidemic alerts based on geographical clustering are useful in targeting the potential reservoir (Stoddard et al. 2014), as was carried out for the Yoyogi Park epidemic, but will, as elsewhere, likely be too late in stopping the spread of the virus beyond the site (Reiter and Gubler 1997). Indeed, viral spread from Yoyogi Park was confirmed in the satellites park with cases and in Shinjuku Gyoen Park in adult mosquitos and may have been implicated in a dengue case in an international student residing adjacent to Yoyogi Park and falling ill upon return to the UK (Kojima 2015).

Diagnosis of imported dengue cases based on a recent history of travel may be misleading. For example, a dengue patient in Hyogo during the 2016 epidemic had stayed in Malaysia for 12–14 days before onset of symptoms, but also had recollection of mosquito bites six days before onset in Hyogo and the virus strain 100% matched with the Yoyogi strain. Unusual above-threshold incidences of dengue may provide an additional criterion for differentiation. Although no official epidemic occurred during the time of disease onset of the German traveller (Schmidt-Chanasit et al. 2014), our alert estimation based on the baseline threshold method did pinpoint to this period as being aberrant. Importantly, while unusually high "above-threshold" dengue incidences were noted during several time periods, there was never any subsequent progression into an epidemic, although the lengthy period above the alert threshold in 2019 is concerning. The recurrent conclusion from our estimations and observations, including the failure of the satellite parks near to Yoyogi Park and Shinjuku Gyoen to progress into comparable epidemics, is that there is substantial stochastic die-out of circulating DENV, despite permissive temperatures. Thus, while there may be significant viral import and climatic conditions highly permissive to transmission, societal factors may be overwhelmingly important and significantly have a negative impact upon viral spread through the population. This notwithstanding, the majority of infections, especially being primary infections, will likely go unnoticed and that the actual spread of DENV may be greater than we realize from surveillance data. Indeed, active serological and behavioural studies were conducted by the NIID on the 375 individuals who frequented Yoyogi Park and its vicinity (National Institute of Infectious Diseases 2021d: www.nih.go.jp/niid/ja/id/693-disease-based/ta/dengue/idsc/iasr-news/5754-pr4252.html). From the serological dengue data obtained from 207 individuals, ten individuals were seropositive for DENV without any travel history and five cases were completely asymptomatic. The comparison between seropositive and seronegative individuals revealed that seropositive individuals were significantly associated with increased length of stay in the park, but not with the individual mosquito prevention efforts. Further seroprevalence studies in and around cases would enable us to understand whether Yoyogi Park was an exception or whether there has been extensive silent DENV transmission.

The added utility of using a threshold approach to detecting aberrant incidence rates for public health activities remains to be developed, but could at least provide a basis for performing seroprevalence studies in and around cases detected during such high incidence weeks. Likewise, the choice of surveillance scale needs to be addressed. Greater Tokyo was sensitive to detecting outliers, but which may be a consequence of aggregating lower incidence prefectures with Tokyo. Insofar as public health decisions are taken at the prefecture level, establishing threshold levels at this scale may be more practical and appropriate.

In conclusion, while increased human movement and permissive temperatures do pose a threat for DENV invasion, evidence suggests that thus far Yoyogi was an exception and that a considerable viral biomass following repeated introduction may be required for successful viral implantation. Seroprevalence studies targeting areas with apparently unusual dengue incidences would go a long way in establishing the extent of the problem, at least for the present.

References

Alves MJ, Fernandes PL, Amaro F, et al (2013) Clinical presentation and laboratory findings for the first autochthonous cases of dengue fever in Madeira island, Portugal, October 2012. Euro Surveill 18:ii 20398

Bhatt S, Gething P, Brady O et al (2013) The global distribution and burden of dengue. Nature 496:504–507. https://doi.org/10.1038/nature12060

Chan M, Johansson MA (2012) The incubation periods of dengue viruses. PLoS ONE 7(11), e50972

Chen LH, Wilson ME (2008) The role of the traveler in emerging infections and magnitude of travel. Med Clin N Am 92:1409–1432. https://doi.org/10.1016/j.mcna.2008.07.005

Duong V, Lambrechts L, Paul RE, et al (2015) Asymptomatic humans transmit dengue virus to mosquitoes. Proc Natl Acad Sci U S A, pp ii: 201508114

Effler PV, Pang L, Kitsutani P et al (2005) Dengue fever, Hawaii, 2001–2002. Emerg Infect Dis 11:742–749

GenStat for Windows 15th Edition. Hemel Hempstead, UK: VSN International Ltd.

Geospatial Information Authority of Japan (2021) Map of geospatial information authority of Japan. http://maps.gsi.go.jp/. Accessed May 3 2021

Grange L, Simon-Loriere E, Sakuntabhai A, et al (2014) Epidemiological risk factors associated with high global frequency of inapparent dengue virus infections. Front Immunol, 5:280. 10.3389

Gubler D (2002) Epidemic dengue/dengue hemorrhagic fever as a public health, social and economic problem in the 21st century. Trends Microbiol 10:100–103

Gubler D, Kuno G (1997) Dengue and dengue hemorrhagic fever. CAB International, Wallingford

Hales S, de Wet N, Maindonald J et al (2002) Potential effect of population and climate changes on global distribution of dengue fever: an empirical model. Lancet 360:830–834

Halstead SB (2007) Dengue. Lancet 370:1644–1652

JTB Tourism Research & Consulting Co. (2021) Japanese outbound tourists statistics. www.tourism.jp/en/tourism-database/stats/outbound/#annual. Accessed 3 May 2021

Kojima G (2015) Autochthonous dengue fever imported to England from Japan, 2014. Emerg Infect Dis 21:182–184. https://doi.org/10.3201/eid2101.141581

Kutsuna S, Kato Y, Moi ML et al (2014) (2015) Autochthonous dengue fever, Tokyo, Japan. Emerg Infect Dis 21(3):517–520. https://doi.org/10.3201/eid2103/141662

La Ruche G, Souarès Y, Armengaud A, et al (2010) First two autochthonous dengue virus infections in metropolitan France, Sept 2010. Euro Surveill 15:ii19676

Lambrechts L, Scott TW, Gubler DJ (2010) Consequences of the expanding global distribution of Aedes albopictus for dengue virus transmission. PLoS Negl Trop Dis4, e646. https://doi.org/10.1371/journal.pntd.0000646

Ministry of Health, Labour and Welfare (2011) Case definition of Dengue. www.mhlw.go.jp/bunya/kenkou/kekkaku-kansenshou11/01-04-19.html. Accessed 3 May 2021

Ministry of Health, Labour and Welfare (2018) Infectious Disease Surveillance System in Japan. www.niid.go.jp/niid/images/epi/nesid/nesid_en.pdf. Accessed 3 May 3 2021

Misslin R, Telle O, Daudé E et al (2016) Urban climate versus global climate change—what makes the difference for dengue? Ann NY Acad Sci. https://doi.org/10.1111/nyas.13084

Murray KO, Rodriguez LF, Herrington E et al (2013) Identification of dengue fever cases in Houston, Texas, with evidence of autochthonous transmission between 2003 and 2005. Vector Borne Zoonotic Dis 13:835–845. https://doi.org/10.1089/vbz.2013.1413

Nakayama E, Kotaki A, Tajima S et al (2016) Two different dengue virus strains in the Japanese epidemics of 2014. Virus Genes 52(5):722–726. https://doi.org/10.1007/s11262-016-1356-4

National Institute of Infectious Diseases (2021) Annual report of Infectious Diseases Weekly Report. www.niid.go.jp/niid/ja/allarticles/surveillance/2270-idwr/nenpou/10115-idwr-nenpo2019.html. Accessed 3 May 2021

National Institute of Infectious Diseases (2021) Infectious Diseases Weekly Report. www.nih.go.jp/niid/ja/idwr.html. Accessed 3 May 2021

National Institute of Infectious Diseases (2021) Notification Trends Among Imported Dengue Cases in Japan. www.nih.go.jp/niid/ja/id/690-disease-based/ta/dengue/idsc/6663-dengue-imported.html. Accessed 3 May 2021

National Institute of Infectious Diseases (2021) Report on the results of active epidemiological investigation of dengue autochthonous infection cases, Infectious Diseases Weekly Report. www.nih.go.jp/niid/ja/id/693-disease-based/ta/dengue/idsc/iasr-news/5754-pr4252.html. Accessed 3 May 2021

Quam MB, Sessions O, Kamaraj US et al (2016) Dissecting Japan's dengue outbreak in 2014. Am J Trop Med Hyg 94(2):409–412. https://doi.org/10.4269/ajtmh.15-0468

Reiter P, Gubler DJ (1997) Surveillance and control of urban dengue vectors. In: Gubler DJ, Kuno G (eds) Dengue and dengue hemorrhagic fever. CAB International, Oxford, pp 425–462

Schmidt-Chanasit J, Emmerich P, Tappe D, et al (2014) Autochthonous dengue virus infection in Japan imported into Germany, Sept 2013. Euro Surveill 19(3):ii 20681

Seki N, Iwashita Y, Moto R, et al (2015) An autochthonous outbreak of dengue type 1 in Tokyo, Japan 2014. Nihon Koshu Eisei Zasshi, 62(5):238–250. Japanese. https://doi.org/10.11236/jph.62.5_238

Senda A, Sakuntabhai A, Inaida S et al (2018) Estimating frequency of probable autochthonous cases of dengue Japan. Emerg Infect Dis 24(9):1705–1708. https://doi.org/10.3201/eid2409.170408

Statistics Bureau, Ministry of Internal Affairs and Communications (2017) The results of national census 2015. www.stat.go.jp/data/kokusei/2015/kekka.html. Accessed 3May 2021

Stoddard ST, Wearing HJ, Reiner RC Jr, et al (2014) Long-term and seasonal dynamics of dengue in Iquitos, Peru. PLoS Negl Trop Dis. https://doi.org/10.1371/journal.pntd.0003003

Sukehiro N, Kida N, Umezawa M, et al (2013) First report on invasion of yellow fever mosquito, Aedes aegypti, at Narita International Airport, Japan in August 2012. Japanese J Infect Dis 66(3):189–194. https://doi.org/10.7883/yoken.66.189

Taniguchi K, Yoshida M, Sunagawa T et al (2008) Imported infectious diseases and surveillance in Japan. Travel Med Infect Dis 6(6):349–354. https://doi.org/10.1016/j.tmaid.2008.07.001

Teissier Y, Paul R, Aubry M, et al (2020) Long-term persistence of monotypic dengue transmission in small size isolated populations, French Polynesia, 1978–2014, PLoS Negl Trop Dis.6 14(3):e0008110. https://doi.org/10.1371/journal.pntd.0008110

Thai KT, Anders KL (2011) The role of climate variability and change in the transmission dynamics and geographic distribution of dengue. Exp Biol Med 236944–54. https://doi.org/10.1258/ebm.2011.010402

Tuberculosis and Infectious Disease Control Division, Health Service Bureau, Ministry of Health, Labour and Welfare (2016) Clinical guideline of mosquito-borne diseases. http://www.mhlw.go.jp/file/06-Seisakujouhou-10900000-Kenkoukyoku/0000112494.pdf. Accessed 3 May 2021

WHO (2015) Dengue and dengue hemorrhagic fever, fact sheet 117.World Health Organization. http://www.who.int/mediacentre/factsheets/fs117/en/. Accessed 5 May 2021

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Fumihiko Matsuda obtained his PhD from Kyoto University Graduate School of Medicine in 1990 under Professor Tasuku Honjo and continued his research with him until 1998. Throughout this period, his work is the organization of the human immunoglobulin heavy-chain variable-region (VH) gene locus. In 1998, he joined Centre National de Genotypage (CNG) in Evry, France, as the head of gene identification. During his stay at CNG for ten years, he played a significant role in numerous comprehensive genetic analyses of multigenetic disorders. Since holding a joint appointment as a Professor of the Center for Genomic Medicine at Kyoto University in 2003, he focused on the trans-ethnic genetic studies of human diseases. Since 2012, he has led an international collaboration with McGill University in genomics and contributed to establishing an International Joint Degree Programme in Genomic Medicine between Kyoto and McGill. The programme was initiated in April 2018. He is currently the Dean of Kyoto-McGill International Collaborative School of Genomic Medicine. Since 2017, he has served as the research director of RADDAR-J, a nationwide rare disease platform programme in Japan supported by AMED.

Professor Matsuda has consistently devoted himself to researching human genetics and genomics by integrated omics analysis of human disorders through various positions he has engaged. He has experience working in France for ten years with international collaborators. He is also promoting international collaborations with Asian countries, including China, Korea, and Thailand, as well as with France, Canada, and the UK.

Professor Matsuda is Chevalier de l'Ordre National du Mérite.

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Chapter 12
Who Are Free from Hypertension, Dyslipidemia, and Diabetes Mellitus in the Middle-Aged and Elderly Population of Japan?

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Abstract In the present study, we explored who are more (less) likely to be diagnosed with mild lifestyle-related diseases (MLDs) defined as hypertension, dyslipidemia, and diabetes mellitus as a whole among middle-aged and elderly persons. Data from 11 years of the Longitudinal Survey of Middle-Aged and Elderly Persons by the Japanese Ministry of Health, Labour and Welfare were used for the analyses. A complementary log–log model was chosen for the analyses. For men, those who drink alcohol were more likely to be diagnosed with MLDs. Former smokers were more likely to be diagnosed with MLDs than current smokers. Men who perform light exercise four days or more per week or those who perform vigorous exercise one to three days per week were less likely to be diagnosed with MLDs than those who did not exercise or exercised about one day per month. Men who take care of eating amounts were more likely to be diagnosed with MLDs. Men who brush teeth after meals were less likely to be diagnosed with MLDs. For women, those who drink alcohol were less likely to be diagnosed with MLDs. Former smokers were more likely to be diagnosed with MLDs than current smokers. Women who perform moderate exercise four days or more per week were more likely to be diagnosed with MLDs than those who did not exercise or exercised about one day per month. Women who take care of their eating amount or take vitamin/mineral supplements were more likely to be diagnosed with MLDs. Women who eat a variety of foods or maintain appropriate body weight levels were less likely to be diagnosed with MLDs. Some of these results are inconsistent with previous studies, are contrary to current understanding, or are not well known. Hence, further studies with a greater focus on causal relationships are required.

The present study is a part of the results of the project "Development of New Indicators for Industry Analysis and EBPM Analysis: Focusing on the Service Industry" at the Research Institute of Economy, Trade and Industry (RIETI). The analysis in the present study was based on questionnaire information from the Ministry of Health, Labour and Welfare's Longitudinal Survey of Middle-aged and Elderly Persons.

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Keywords Hypertension · Dyslipidemia · Diabetes mellitus · Mild lifestyle-related diseases (MLDs) · Longitudinal survey of middle-aged and elderly persons

1 Introduction

In Japan, several chronic diseases are called "lifestyle-related diseases" (LRDs) (seikatsu shukan byou). In addition to serious diseases such as cancer, stroke, and myocardial infarction, risk factors of them such as hypertension, dyslipidemia, and diabetes mellitus are also regarded as LRDs. For the present study, we define hypertension, dyslipidemia, and diabetes mellitus as mild lifestyle-related diseases (MLDs). According to the Patient Survey (kanja chousa) carried out by the Ministry of Health, Labour and Welfare (MHLW) in 2017, the total number of patients with MLDs was 9,937,000 for hypertension, 3,289,000 for diabetes mellitus, and 2,205,000 for dyslipidemia. These numbers are limited to people who continuously receive medical care, suggesting that more people have MLDs without being diagnosed. One estimation shows that there are 43 million people in Japan with hypertension (Miura et al. 2013).

According to the Overview of National Medical Expenses in 2017 by MHLW, medical expenses for MLDs are 1.79 trillion yen for hypertension and 1.22 trillion yen for diabetes mellitus (dyslipidemia not shown). Prevention of MLDs is expected to reduce the number of visits to medical institutions, make it easier for people to feel healthy, and decrease medical expenses. Medical institutions may experience a downside that their revenue decreases. However, there is a positive side that valuable medical resources can be shifted to responding to serious diseases. Prevention of MLDs can also reduce the financial burden on national and local governments and corporate health insurance society.

From the perspective of reducing visits to healthcare providers, it would be desirable to be able to prevent all three MLDs—hypertension, dyslipidemia, and diabetes mellitus—simultaneously, because any one of the diagnosed MLDs would result in a recommendation to seek medical consultation. However, previous studies have shown that it is not easy to prevent all three MLDs simultaneously.

For example, alcohol intake has been found to raise blood pressure levels (Roerecke et al. 2017) while reducing LDL-C (so-called bad cholesterol), thus leading to the prevention of dyslipidemia (Vu et al. 2016). With regard to diabetes mellitus, studies have shown that people who drink moderately have a lower risk of developing diabetes mellitus than non-drinkers (Li et al. 2016). Since abstention from drinking may prevent hypertension but may instead increase dyslipidemia and diabetes mellitus, it is unclear whether abstaining from alcohol consumption reduces MLDs as a whole.

Another example to suggest the difficulty of preventing all three MLDs simultaneously is a relationship between socio-economic status and MLDs. Oshio and Kan (2019a) showed that people with higher level of education were less likely to have hypertension (for women only) and diabetes mellitus, but more likely to have dyslipidemia. Thus, it is unclear whether attaining a high level of education reduces MLDs as a whole.

With these issues in mind, the present study attempts to determine who is more likely to be diagnosed with any one of the three MLDs focusing on socio-economic status and lifestyle. For our analyses, we used the raw data from the Longitudinal Survey of Middle-aged and Elderly Persons (LSM), an annual longitudinal questionnaire survey conducted by the Japanese Ministry of Health, Labour and Welfare (MHLW).

2 Method

2.1 Dataset

The present study used individual data from the LSM conducted by MHLW every year since 2005. As of the end of October 2005, the LSM targeted people aged 50–59 in 2515 districts randomly selected from survey areas of the Comprehensive Survey of Living Conditions in 2004. The LSM was conducted for a week beginning on the first Wednesday of November. Up to the fifth survey, it was conducted through home visits by surveyors. Since the sixth survey, it has been carried out by mail. The number of survey respondents in the first survey was 40,877, and 34,240 people responded (response rate was 83.8%). Since the second year, only those who participated in the survey of one or two preceding years remained contacted. In the present study, the answers from the first survey to the 11th survey were used. In the 11th survey, the number of people who were sent the questionnaire was 23,485, and the number of collected responses was 22,595 (response rate was 96.2%).

2.2 Measures

2.2.1 Primary and Secondary Outcomes

In the LSM, respondents were asked whether they were presently diagnosed with any of the relevant conditions or diseases by a doctor. Those diseases include each one of the three MLDs: hypertension, dyslipidemia, and diabetes mellitus. Using the answers to this diagnosis-related question, people who were diagnosed with at least one of the three MLDs were defined as people who were presently diagnosed with MLDs and were defined as primary outcomes. Each diagnosis of hypertension, dyslipidemia, and diabetes mellitus was used as secondary outcomes.

2.2.2 Explanatory Variables

Socio-Economic Status

Explanatory variables related to socio-economic status include final educational background (0: junior high school, 1: senior high school, 2: junior college/vocational school/other, 3: four-year college/graduate school), marital status (0: married, 1: divorced or bereaved, 2: never married), and the employment status (0: currently in the workforce to be paid, 1: not currently in the workforce to be paid). The LSM has questions about income and savings. However, due to the low response rate, these variables were not used in the present study.

Variables Related to Lifestyle

Smoking We created a categorical variable consisting of three categories: those who smoke, those who quit smoking, and those who have never smoked.

Alcohol intake The LSM asked both questions about the frequency of drinking alcohol and the average amount of alcohol intake at each drinking occasion. They were converted into a single variable. In this conversion, we multiply the frequency by the average amount based on the following formula. For the frequency, the frequency was converted to 0.5 for frequency 1–3 days per month, 1.5 for 1–2 days per week, 3.5 for 3–4 days per week, 5.5 for 5–6 days per week, and 7 for every day (Saito et al. 2018). For the average amount, respondents are requested to convert their alcohol intake in unis to gou which is used for Japanese sake and equivalent to 22 g of ethanol. Less than 1 gou was counted as 1, 1–3 gous was counted as 2, 3–5 gous was counted as 3, and 5 or more gous were counted as 4. We multiplied frequency by the average amount based on this formula and classified the multiplied amount into five grades. Grade 0 was “rarely drink” or “never” (unable to drink). Grade 1 was 1–3 days a month with an average of less than 5 gous per day or 1–2 days a week with an average of less than 1 gou per day. Grade 2 was 1–3 days a month with an average of 5 or more gous per day or 1–2 days a week with an average of 1 gou per day or more, or 3–4 days a week with an average amount of less than three gous, or 5–7 days a week with an average amount of less than one gou. Grade 3 was 3–4 days a week with an average amount of three or more gous, or 5–7 days a week with an average amount of between one to three gous. Grade 4 was 5–7 days a week with an average amount of three or more gous.

Physical exercise In the LSM, the questions regarding physical exercise are subdivided into (1) light exercises, which do not cause a shortness of breath (for example, stretching), (2) moderate exercises, which causes a slight shortness of breath (for example, walking and jogging), and (3) vigorous exercises, which causes a severe shortness of breath (for example, aerobics and swimming). For each of these three categories, six choices are shown, which are “no exercise”, “about 1 day a month”, "about 1 day a week", "2–3 days a week", "4–5 days a week", and "almost every day". Since the original questions on exercise are difficult to use as explanatory variables as they are, they were reclassified as follows and a dummy variable with 0 as a reference category was created.

Grade 0: Not exercising or about 1 day a month for any of the three types of exercises

Grade 1: Performed only light exercise 1–3 days a week

Grade 2: Performed only light exercise 4 days a week or more

Grade 3: Performed moderate exercise 1–3 days a week (with no vigorous exercise or about 1 day a month only)

Grade 4: Performed moderate exercise more than 4 days a week (with no vigorous exercise or about 1 day a month only)

Grade 5: Performed vigorous exercise 1–3 days a week

Grade 6: Performed vigorous exercise more than 4 days a week

Moreover, we assumed that the larger the grade indicated, the more intense the exercise. Based on this assumption, we analyzed the exercise variable both as a categorical variable and a continuous variable.

Practices to care for health In the LSM, there is a question item "Do you have something that you keep in mind to maintain good health? Please circle all applicable numbers". These are as follows.

1. I do not drink too much.
2. I do not smoke too much.
3. I do moderate exercise.
4. I have a health check-up at least once a year.
5. I take care of the amount of food I take.
6. I take a variety of foods in consideration of balance.
7. I take vitamin/mineral in tablet, capsule, granule or drink form.
8. I maintain proper weight.
9. I brush my teeth after meals.
10. I take an adequate rest.
11. I do not accumulate stress.
12. Others.
13. Nothing in particular.

Since the LSM has more detailed questions on numbers 1, 2, 3, and 4, we did not use them in the present study. Numbers 12 and 13 were not used in the analysis. As a result, the question items 5, 6, 7, 8, 9, 10, and 11 were used as explanatory variables in the analysis as dummy variables (1 if present, 0 if not).

Social participation activities In the LSM, social participation activities are composed of six items: "hobbies and culture", "sports and health", "community events", "support of child-raising", "support for the elderly", and "other social participation activities". Oshio and Kan (2019b) used the LSM to examine the relationship between social participation in at least one of the six types of social participation activities and each of the three MLDs separately, and found that those who participated in social participation activities were less likely to be diagnosed with diabetes mellitus in both men and women, only women were less likely to be diagnosed with hypertension, whereas both men and women were more likely to be diagnosed with dyslipidemia. However, Oshio and Kan (2019b) did not distinguish participation in sports activities from other social participation activities and incorporated them into one social participation category, which makes it difficult to discriminate between social participation activities and physical exercise, which is by itself associated with MLDs (Colberg et al. 2016; Gordon et al. 2016; Hagberg et al. 2000). Therefore, we did not include sports in social participation activities in the present study. In addition, among the remaining items, we did not treat "hobbies and culture" as a social participation activity and created a separate explanatory variable. We created a categorical variable with 0 for those who did not participate in any of the remaining four categories and 1 for those who participated in any of the four remaining items.

Other explanatory variables Other explanatory variables were (1) age (continuous values), (2) whether or not caring for parents or spouse's parents (1 if present, 0 if absent), and (3) whether or not they had difficulties in activities of daily living (1 if present, 0 if absent). We also created a binary variable for health check-ups, which takes 1 if the patient had a health checkup and 0 if he or she did not have a health check-up. We included prefecture dummies and year dummies in the variables.

2.3 Statistical Analysis

To avoid the reverse causality from the diagnosis of MLDs to the explanatory variables, the estimation samples were limited to the respondents who were not diagnosed with any of the three MLDs in each year (year t). The dependent variable was the binary variable that was 1 if they were diagnosed with any one of the three MLDs in year $t + 1$ and 0 if they were diagnosed with none of the MLDs in year $t + 1$. The explanatory variables were the values of year t. However, for the health check-up, both values of year t and year $t + 1$ were included in the explanatory variables to adjust for the possibility that the latest health check-up would increase the diagnosis of MLDs. Since outcome variables were observed every year, we decided to rely on the discrete-time methods and adopted the complementary log–log model to calculate the hazard ratio (Allison 1982; Singer and Willett 1993, 2003). Once respondents were diagnosed with any one of MLDs, they were excluded from the estimation samples next year and thereafter. Each of hypertension, diabetes mellitus and dyslipidemia was analyzed in the same way as MLDs as a whole.

The analyses were carried out separately for men and women. Statistical analyses were performed using STATA 15, with a significance level of 5% on both sides.

3 Results

3.1 Characteristics of Study Respondents

Table 1 shows the respondents' characteristics for both genders in 2005 and 2016. The number of respondents and the ratios of people with a diagnosis of MLDs are shown graphically in Fig. 1 for men and Fig. 2 for women. The proportion of people with a diagnosis of MLDs tends to increase as the respondents get older, with the proportion of people with any diagnosis of MLDs exceeding 50% in 2012 and 2016 for men and women, respectively. In terms of gender differences, men were more likely than women to be diagnosed with hypertension and diabetes mellitus, and the opposite is true for dyslipidemia.

3.2 Age, Final Education, and Marital Status

With respect to age, as shown in Table 2, new diagnoses of MLDs increased by 4% for each additional year of age in men (hazard ratio 1.04; 95% confidence interval, 1.03–1.05). Regarding each of the three MLDs, there was a significant increase in hypertension and diabetes mellitus, but no significant difference in dyslipidemia. As shown in Table 3, new diagnoses of MLDs increased by 5% for each additional year of age in women (hazard ratio 1.05; 95% confidence interval, 1.03–1.06). Individually, there was a significant increase in all three MLDs.

Across the four different final educational levels, no significant difference was found in the new diagnoses of MLDs with respect to men. Regarding each of the three MLDs, four-year college graduates were less likely to be diagnosed with hypertension and diabetes mellitus and more likely to be diagnosed with dyslipidemia than junior high school graduates. This suggests that non-significant difference in MLDs as a whole between junior high school graduates and four-year college graduates is a result of opposite trends between less diagnoses with hypertension and diabetes mellitus and more diagnoses with dyslipidemia for four-year college students in comparison with junior high school graduates. Among females, senior high school graduates were less likely to be diagnosed with MLDs than junior high school graduates (hazard ratio 0.86; 95% confidence interval, 0.78–0.96). Senior high school graduates were less likely to be diagnosed with hypertension and diabetes mellitus than junior high school graduates, but there was no significant difference in dyslipidemia.

Across the three different marital statuses studied here, no significant difference was found in the new diagnoses of MLDs with respect to either men or women. However, women who had experienced divorce or bereavement and never-married women were less likely to be diagnosed with hypertension and more likely to be diagnosed with dyslipidemia than presently married women. This suggests that non-significant difference in MLDs as a whole between women who were presently married and women who were divorced or bereaved is a result of opposite trends

Table 1 Respondents' characteristics in 2005 and 2016

	Men in 2005		Women in 2005		Men in 2016		Women in 2016	
	N	%	N	%	N	%	N	%
Total number of respondents	16,409		17,394		10,152		11,757	
Age (mean, standard deviation)	55.2	(2.7)	55.2	(2.7)	66.3	(2.7)	66.3	(2.7)
Final education	92.1%		92.4%		98.8%		98.9%	
Junior high school	2935	19.4%	2964	18.4%	1695	16.9%	1953	16.8%
Senior high school	7033	46.5%	8225	51.2%	4724	47.1%	6068	52.2%
Junior college or vocational school	1315	8.7%	3814	23.7%	892	8.9%	2806	24.1%
Four-year college or graduate school	3837	25.4%	1076	6.7%	2721	27.1%	801	6.9%
Marital status	99.7%		99.6%		98.4%		98.2%	
Presently married	14,228	87.0%	14,672	84.7%	8672	86.8%	9058	78.5%
Divorced or bereaved	903	5.5%	1983	11.5%	771	7.7%	2134	18.5%
Never married	1225	7.5%	669	3.9%	545	5.5%	351	3.0%
Alcohol intake	97.5%		97.1%		98.7%		98.6%	

(continued)

Table 1 (continued)

	Men in 2005		Women in 2005		Men in 2016		Women in 2016	
Grade 0	4317	27.0%	11,908	70.5%	3245	32.4%	8432	72.8%
Grade 1	1338	8.4%	1912	11.3%	851	8.5%	1187	10.2%
Grade 2	3696	23.1%	2193	13.0%	2189	21.8%	1415	12.2%
Grade 3	5424	33.9%	776	4.6%	3325	33.2%	514	4.4%
Grade 4	1217	7.6%	108	0.6%	412	4.1%	43	0.4%
Smoking	99.4%		98.3%		99.5%		99.3%	
Currently smoking	7993	49.0%	2253	13.2%	2717	26.9%	765	6.6%
Quitted smoking	5817	35.7%	1476	8.6%	5105	50.5%	1445	12.4%
Never smoked	2503	15.3%	13,369	78.2%	2284	22.6%	9469	81.1%
Physical exercise	93.6%		93.6%		99.0%		98.6%	
Grade 0	8460	55.1%	7313	44.9%	3595	35.8%	3563	30.7%
Grade 1	1407	9.2%	2132	13.1%	1057	10.5%	1797	15.5%
Grade 2	1374	9.0%	1874	11.5%	1082	10.8%	1457	12.6%
Grade 3	2153	14.0%	2167	13.3%	1983	19.7%	2364	20.4%
Grade 4	1201	7.8%	1563	9.6%	1664	16.6%	1477	12.7%
Grade 5	646	4.2%	1087	6.7%	537	5.3%	786	6.8%
Grade 6	110	0.7%	146	0.9%	133	1.3%	151	1.3%
General health check within a year	99.0%		98.7%		98.9%		98.2%	

(continued)

Table 1 (continued)

	Men in 2005		Women in 2005		Men in 2016		Women in 2016	
No	3606	22.2%	5362	31.2%	3220	32.1%	4132	35.8%
Yes	12,636	77.8%	11,804	68.8%	6817	67.9%	7419	64.2%
Currently in the workforce to be paid	99.9%		99.8%		99.8%		99.7%	
No	1086	6.6%	5486	31.6%	3504	34.6%	6621	56.5%
Yes	15,301	93.4%	11,875	68.4%	6630	65.4%	5097	43.5%
Difficulty in daily activities	95.5%		94.9%		95.7%		95.3%	
No	14,634	93.4%	14,802	89.7%	8600	88.5%	9316	83.2%
Yes	1038	6.6%	1698	10.3%	1116	11.5%	1883	16.8%
Hobby and cultural activities	91.2%		91.2%		97.1%		95.6%	
No	6674	44.6%	6000	37.8%	3749	38.1%	3572	31.8%
Yes	8286	55.4%	9858	62.2%	6104	62.0%	7665	68.2%
Social participation activities	91.2%		91.2%		97.0%		95.5%	
No	10,187	68.1%	10,569	66.7%	4595	46.7%	5202	46.4%
Yes	4773	31.9%	5289	33.4%	5249	53.3%	6022	53.7%
Practices to care for health								

(continued)

Table 1 (continued)

	Men in 2005		Women in 2005		Men in 2016		Women in 2016	
Taking care of eating amounts	100.0%		100.0%		100.0%		100.0%	
No	10,509	64.0%	9413	54.1%	4640	45.7%	4516	38.4%
Yes	5900	36.0%	7981	45.9%	5512	54.3%	7241	61.6%
Taking a variety of foods	100.0%		100.0%		100.0%		100.0%	
No	11,894	72.5%	9116	52.4%	6308	62.1%	5071	43.1%
Yes	4515	27.5%	8278	47.6%	3844	37.9%	6686	56.9%
Taking vitamin/mineral supplements	100.0%		100.0%		100.0%		100.0%	
No	13,667	83.3%	12,993	74.7%	8323	82.0%	9062	77.1%
Yes	2742	16.7%	4401	25.3%	1829	18.0%	2695	22.9%
Maintaining proper body weight	100.0%		100.0%		100.0%		100.0%	
No	11,063	67.4%	10,534	60.6%	5284	52.1%	5825	49.5%
Yes	5346	32.6%	6860	39.4%	4868	48.0%	5932	50.5%
Brushing teeth after a meal	100.0%		100.0%		100.0%		100.0%	
No	12,242	74.6%	10,295	59.2%	6188	61.0%	5319	45.2%
Yes	4167	25.4%	7099	40.8%	3964	39.1%	6438	54.8%

(continued)

Table 1 (continued)

	Men in 2005		Women in 2005		Men in 2016		Women in 2016	
Taking moderate rest	100.0%		100.0%		100.0%		100.0%	
No	11,053	67.4%	10,616	61.0%	6233	61.4%	6301	53.6%
Yes	5356	32.6%	6778	39.0%	3919	38.6%	5456	46.4%
Not accumulating stress	100.0%		100.0%		100.0%		100.0%	
No	10,132	61.8%	9427	54.2%	5478	54.0%	5732	48.8%
Yes	6277	38.3%	7967	45.8%	4674	46.0%	6025	51.3%
Caring for a relative	95.3%		95.4%		96.3%		95.7%	
No	14,659	93.7%	14,861	89.6%	8742	89.4%	9749	86.7%
Yes	983	6.3%	1734	10.5%	1037	10.6%	1498	13.3%

Note Underlined percentages is the ratio of those who answered the question divided by the total number of respondents. For items in "paying attention to health activities", respondents are asked to place a checkmark if each item is applied to him/her. We treated not placing a checkmark as No to the item. Hence, the underlined percentages are 100% for them

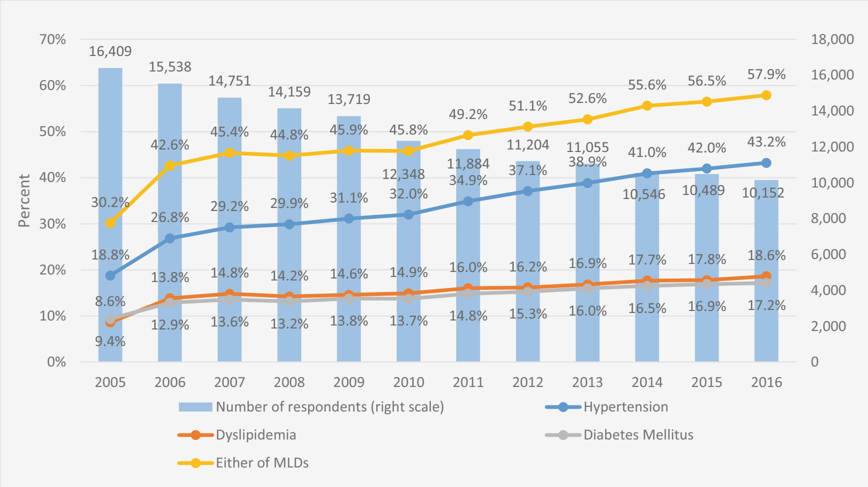

Fig. 1 Ratio of those who are diagnosed with hypertension, dyslipidemia, or diabetes mellitus (men). *Note* The ratio of answering yes to the diagnosis of each disease category on the total responses to the questions is shown in the line graphs (missing data are not included in the denominator). The bar graph shows the total number of responses, including those who did not respond to the question of whether they had a diagnosis. Mild lifestyle-related diseases (MLDs) are defined as hypertension, dyslipidemia, and diabetes mellitus as a whole

between less diagnoses with hypertension and more diagnoses with dyslipidemia for women who were divorced or bereaved in comparison with women who were presently married.

3.3 Alcohol Intake

There was a significant increase in MLDs overall in men at alcohol intake levels of grades 3 and 4 in comparison with grade 0 (those who drink little or no alcohol). There was a significant increase in hypertension at grades 2, 3, and 4 in comparison with grade 0, while there was a significant decrease in dyslipidemia at grades 2 and 3 and a significant decrease in diabetes mellitus at grade 3. An increase in hypertension and a decrease in dyslipidemia and diabetes mellitus at grade 3 suggests that there is a opposite trend between hypertension and the other two MLDs.

Women showed a significant decrease in overall MLDs at grade 2 in comparison with grade 0. Otherwise, there was no significant difference. While there was a significant increase in hypertension at grade 3 compared to grade 0, there was a significant decrease in dyslipidemia and diabetes mellitus at grades 2 and 3, suggesting that there is a trade-off between the increasing trend in hypertension and the decreasing trend in dyslipidemia and diabetes mellitus.

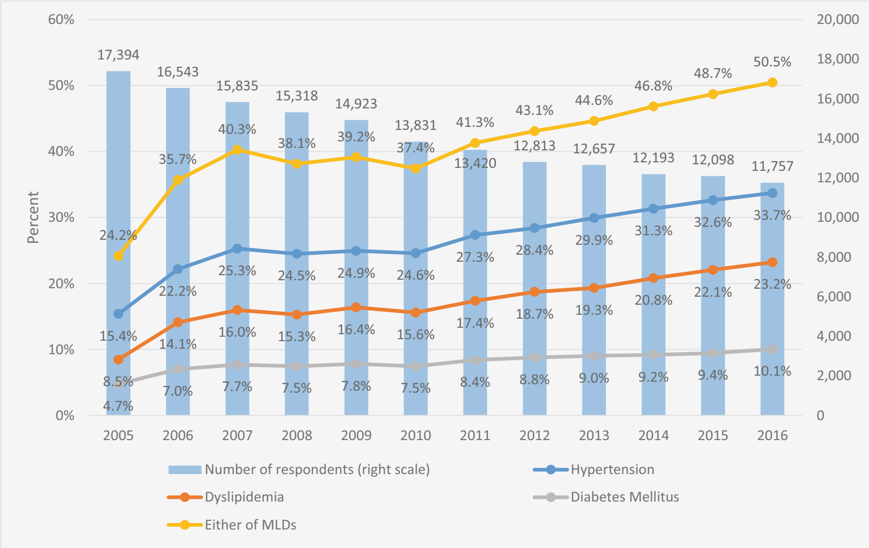

Fig. 2 Ratio of those who are diagnosed with hypertension, dyslipidemia, or diabetes mellitus (women). *Note* The ratio of answering yes to the diagnosis of each disease category on the total responses to the questions is shown in the line graphs (missing data are not included in the denominator). The bar graph shows the total number of responses, including those who did not respond to the question of whether they had a diagnosis. Mild lifestyle-related diseases (MLDs) are defined as hypertension, dyslipidemia, and diabetes mellitus as a whole

3.4 Smoking

For men, those who quit smoking had a 22% increase (hazard ratio 1.22; 95% confidence interval, 1.13–1.32) for overall MLDs diagnoses compared to smokers, with significant increases in hypertension and dyslipidemia and no significant difference in diabetes mellitus. When those who never smoked were compared with smokers, there was no significant difference in MLDs overall, but there was a significant increase in hypertension, with a significant decrease in diabetes mellitus, and no significant difference in dyslipidemia, suggesting a trade-off between hypertension and diabetes mellitus.

For women, those who quit smoking had a 19% increase (hazard ratio 1.19; 95% confidence interval, 1.03–1.39) for MLDs overall compared to smokers, with a significant increase for dyslipidemia and no significant difference for hypertension and diabetes mellitus. When those who never smoked were compared with smokers, there was no significant difference in MLDs overall, with no significant difference in hypertension and dyslipidemia, and a significant decrease in diabetes mellitus.

Table 2 Analysis of new diagnoses of MLDs (men)

	MLDs	Hypertension	Dyslipidemia	Diabetes
Age	**1.04******[1.03,1.05]**	**1.04******[1.03,1.06]**	1.01 [0.99,1.02]	**1.04******[1.02,1.06]**
Final education (reference: junior high school)				
Senior high school	0.97 [0.88,1.07]	0.97 [0.88,1.08]	**1.14*****[1.01,1.29]**	0.88 [0.76,1.02]
Junior college or vocational school	0.96 [0.84,1.11]	0.94 [0.81,1.09]	1.05 [0.88,1.24]	0.91 [0.73,1.13]
Four-year college or graduate school	0.94 [0.84,1.05]	**0.87*****[0.77,0.98]**	**1.21******[1.05,1.38]**	**0.70******[0.59,0.83]**
Marriage (reference: presently married)				
Divorced or bereaved	1.08 [0.94,1.26]	1.13 [0.97,1.31]	1.07 [0.90,1.26]	1.17 [0.94,1.44]
Never married	1.02 [0.88,1.18]	0.98 [0.83,1.15]	0.96 [0.80,1.14]	1.10 [0.88,1.37]
Alcohol intake (reference: Grade 0 (little or no drinking))				
Grade 1	1.01 [0.88,1.14]	1.02 [0.87,1.18]	0.94 [0.82,1.09]	0.99 [0.81,1.21]
Grade 2	1.01 [0.92,1.11]	**1.28******[1.15,1.42]**	**0.81******[0.72,0.90]**	0.97 [0.84,1.12]
Grade 3	**1.21******[1.12,1.32]**	**1.73******[1.57,1.90]**	**0.78******[0.71,0.87]**	**0.85*****[0.75,0.98]**
Grade 4	**1.36******[1.18,1.58]**	**1.97******[1.69,2.30]**	0.89 [0.75,1.06]	1.09 [0.88,1.36]
Smoking (reference: Currently smoking)				
Quitted smoking	**1.22******[1.13,1.32]**	**1.24******[1.14,1.34]**	**1.20******[1.09,1.31]**	0.97 [0.87,1.10]
Never smoked	1.09 [0.98,1.20]	**1.14*****[1.02,1.27]**	1.01 [0.90,1.14]	**0.83*****[0.71,0.98]**
Frequency and intensity of physical exercise (reference: Grade 0 (none or once a month for any exercise))				
Grade 1	1.07 [0.96,1.20]	1.02 [0.90,1.15]	1.08 [0.95,1.23]	0.98 [0.82,1.17]
Grade 2	**0.87*****[0.77,0.98]**	0.89 [0.78,1.01]	0.89 [0.77,1.02]	**0.82*****[0.67,0.99]**
Grade 3	1.03 [0.93,1.13]	0.94 [0.84,1.04]	1.05 [0.94,1.17]	0.91 [0.78,1.06]
Grade 4	1.06 [0.94,1.19]	0.99 [0.88,1.12]	0.94 [0.82,1.08]	1.01 [0.84,1.20]
Grade 5	**0.80******[0.68,0.95]**	**0.77******[0.64,0.93]**	0.87 [0.72,1.05]	**0.63******[0.46,0.86]**
Grade 6	0.92 [0.65,1.30]	0.81 [0.54,1.20]	0.74 [0.46,1.20]	1.05 [0.60,1.83]
Taking general health check				
Yes for present year (reference: No)	**2.30******[2.07,2.55]**	**1.83******[1.65,2.04]**	**1.94******[1.71,2.19]**	**1.76******[1.51,2.05]**
Yes for last year (reference: No)	**0.84******[0.77,0.93]**	**0.76******[0.68,0.83]**	1.12 [1.00,1.26]	**0.78******[0.68,0.90]**
Currently in the workforce to be paid	1.01 [0.90,1.14]	1.01 [0.90,1.14]	0.97 [0.85,1.10]	0.97 [0.82,1.13]

(continued)

Table 2 (continued)

	MLDs	Hypertension	Dyslipidemia	Diabetes
Difficulty in daily activities	**1.35**[1.18,1.54]**	**1.43**[1.25,1.63]**	**1.21*[1.04,1.40]**	**1.69**[1.43,2.01]**
Hobbies or cultural activities	0.99 [0.92,1.06]	0.97 [0.89,1.04]	1.09 [1.00,1.18]	0.96 [0.86,1.08]
Social participation activities	**1.09*[1.02,1.17]**	1.01 [0.93,1.09]	1.05 [0.97,1.14]	1.03 [0.92,1.15]
Practices to care for health (reference: No)				
Taking care of eating amount	**1.15**[1.07,1.24]**	1.07 [0.99,1.16]	**1.13**[1.04,1.24]**	**1.30**[1.15,1.46]**
Taking a variety of foods	0.96 [0.89,1.04]	**0.92*[0.84,1.00]**	1.03 [0.95,1.13]	0.99 [0.88,1.12]
Take vitamin/mineral supplements	1.07 [0.99,1.17]	1.06 [0.97,1.16]	**1.13* [1.03,1.25]**	0.96 [0.84,1.10]
Maintaining proper body weight	0.94 [0.87,1.01]	0.97 [0.89,1.05]	0.92 [0.84,1.00]	**0.88*[0.78,0.98]**
Brushing teeth after meal	**0.89**[0.83,0.96]**	**0.81**[0.75,0.88]**	0.97 [0.89,1.06]	**0.85*[0.75,0.96]**
Taking moderate rest	0.94 [0.87,1.01]	1.01 [0.94,1.10]	**0.91*[0.84,0.99]**	**0.87*[0.77,0.98]**
Not accumulating stress	1.02 [0.95,1.10]	**1.09*[1.01,1.18]**	1.04 [0.96,1.13]	0.98 [0.87,1.09]
Caring for a relative	1.08 [0.96,1.22]	0.98 [0.86,1.11]	**1.19*[1.04,1.35]**	**1.28**[1.08,1.51]**
N	41,200	58,609	70,480	79,508

Note A discrete hazard model was adopted and a complementary log–log model was used to show the hazard ratios and 95% confidence intervals. The dependent variable was a binary variable for people who did not receive a diagnosis of each lifestyle disease in each year (the year t) between 2005 and 2015, with 0 if they did not receive a diagnosis in the year t + 1 and 1 if they did. The explanatory variable was the value for the year t except for the general health check. See text for grades of alcohol consumption and physical excercise. ** 1% significant * 5% significant. MLDs = mild lifestyle-related diseases

3.5 Physical Exercise

For MLDs overall in men, there was a 13% decrease (hazard ratio 0.87; 95% confidence interval, 0.77–0.98) in those who performed only light exercise four or more days per week (grade 2) and a 20% decrease (hazard ratio 0.80; 95% confidence interval, 0.68–0.95) in those who performed vigorous exercise 1–3 days per week (grade 5) compared to those who did not exercise or about 1 day per month (grade

Table 3 Analysis of new diagnoses of MLDs (women)

	MLDs	Hypertension	Dyslipidemia	Diabetes
Age	**1.05**[**]**[1.03,1.06]**	**1.06**[**]**[1.04,1.08]**	**1.03**[**]**[1.01,1.04]**	**1.07**[**]**[1.05,1.10]**
Final education (reference: junior high school)				
Senior high school	**0.86**[**]**[0.78,0.96]**	**0.79**[**]**[0.70,0.89]**	1.06 [0.95,1.19]	**0.67**[**]**[0.56,0.80]**
Junior college or vocational school	0.93 [0.83,1.04]	**0.76**[**]**[0.67,0.88]**	1.13 [1.00,1.29]	**0.70**[**]**[0.57,0.86]**
Four-year college or graduate school	0.86 [0.74,1.01]	**0.65**[**]**[0.53,0.79]**	1.12 [0.94,1.33]	**0.53**[**]**[0.39,0.74]**
Marriage (reference: presently married)				
Divorced or bereaved	0.99 [0.89,1.10]	**0.83**[**]**[0.73,0.94]**	**1.12**[*]**[1.00,1.25]**	0.93 [0.77,1.14]
Never married	0.98 [0.82,1.18]	**0.77**[*]**[0.61,0.98]**	1.02 [0.83,1.25]	0.88 [0.60,1.27]
Alcohol intake (reference: Grade 0 (little or no drinking))				
Grade 1	0.98 [0.88,1.09]	0.97 [0.85,1.11]	1.01 [0.90,1.13]	0.82 [0.66,1.02]
Grade 2	**0.84**[**]**[0.76,0.93]**	1.04 [0.91,1.17]	**0.80**[**]**[0.71,0.90]**	**0.70**[**]**[0.56,0.87]**
Grade 3	0.89 [0.76,1.06]	**1.49**[**]**[1.24,1.79]**	**0.58**[**]**[0.47,0.72]**	**0.43**[**]**[0.28,0.66]**
Grade 4	0.99 [0.62,1.59]	1.61 [0.98,2.65]	0.84 [0.48,1.45]	0.18 [0.03,1.28]
Smoking (reference: Currently smoking)				
Quitted smoking	**1.19**[*]**[1.03,1.39]**	1.19 [0.99,1.44]	**1.22**[*]**[1.03,1.44]**	1.01 [0.77,1.33]
Never smoked	1.00 [0.88,1.13]	1.06 [0.91,1.24]	0.97 [0.84,1.11]	**0.73**[**]**[0.59,0.92]**
Frequency and intensity of physical exercise (reference: Grade 0 (none or once a month for any exercise))				
Grade 1	1.05 [0.94,1.17]	0.90 [0.79,1.03]	1.12 [1.00,1.26]	0.94 [0.77,1.15]
Grade 2	1.09 [0.97,1.22]	1.03 [0.91,1.18]	1.07 [0.95,1.21]	0.88 [0.71,1.10]
Grade 3	1.06 [0.96,1.17]	0.91 [0.80,1.03]	**1.12**[*]**[1.01,1.25]**	0.86 [0.70,1.06]
Grade 4	**1.26**[**]**[1.12,1.41]**	1.14 [1.00,1.30]	**1.21**[**]**[1.07,1.37]**	1.12 [0.90,1.39]
Grade 5	0.87 [0.75,1.00]	**0.80**[*]**[0.67,0.96]**	0.92 [0.78,1.08]	0.99 [0.73,1.33]
Grade 6	0.96 [0.69,1.34]	1.06 [0.73,1.54]	0.76 [0.50,1.15]	1.62 [0.95,2.78]
Taking general health check				
Yes for present year (reference: No)	**2.42**[**]**[2.20,2.66]**	**1.76**[**]**[1.58,1.97]**	**2.47**[**]**[2.22,2.76]**	**1.71**[**]**[1.44,2.03]**
Yes for last year (reference: No)	0.94 [0.86,1.02]	**0.84**[**]**[0.76,0.93]**	**1.17**[**]**[1.06,1.29]**	**0.78**[**]**[0.66,0.91]**
Currently in the workforce to be paid	1.00 [0.93,1.08]	1.02 [0.94,1.12]	0.98 [0.91,1.06]	0.92 [0.80,1.06]

(continued)

Table 3 (continued)

	MLDs	Hypertension	Dyslipidemia	Diabetes
Difficulty in daily activities	**1.29****[1.16,1.44]**	**1.27****[1.12,1.44]**	**1.16***[1.03,1.30]**	**1.74****[1.47,2.07]**
Hobbies or cultural activities	0.95 [0.88,1.02]	**0.84****[0.77,0.93]**	1.05 [0.97,1.15]	0.89 [0.77,1.02]
Social participation activities	0.96 [0.90,1.03]	0.93 [0.85,1.01]	0.96 [0.89,1.03]	0.88 [0.77,1.01]
Practices to care for health (reference: No)				
Taking care of eating amount	**1.14****[1.06,1.23]**	**1.15****[1.05,1.26]**	**1.19****[1.09,1.29]**	**1.28****[1.11,1.48]**
Taking a variety of foods	**0.92***[0.86,0.99]**	0.94 [0.86,1.03]	0.95 [0.87,1.03]	**0.81****[0.70,0.94]**
Take vitamin/mineral supplements	**1.10***[1.02,1.18]**	1.06 [0.97,1.16]	**1.10***[1.01,1.20]**	1.11 [0.96,1.29]
Maintaining proper body weight	**0.85****[0.79,0.92]**	**0.77****[0.70,0.84]**	**0.91***[0.84,0.99]**	**0.73****[0.63,0.85]**
Brushing teeth after meal	0.94 [0.88,1.01]	0.92 [0.84,1.00]	0.96 [0.89,1.04]	**0.79****[0.69,0.91]**
Taking moderate rest	1.03 [0.96,1.11]	1.04 [0.95,1.14]	0.98 [0.90,1.06]	1.01 [0.88,1.17]
Not accumulating stress	1.00 [0.93,1.08]	**1.13****[1.03,1.23]**	0.96 [0.89,1.04]	0.99 [0.87,1.14]
Caring for a relative	**1.11***[1.01,1.23]**	0.99 [0.88,1.12]	1.10 [0.99,1.22]	1.12 [0.93,1.34]
N	50,800	69,115	72,416	90,075

Note Same as the note in Table 2

0). Other categories (light exercise 1–3 days per week (grade 1), moderate exercise 1 or more days per week (grade 3 and 4), and vigorous exercise 4 or more days per week (grade 6)) had no difference in overall MLDs compared with those who did not exercise or about 1 day per month. When the exercise was treated as a continuous value, there was no significant trend for MLDs overall (hazard ratio 0.99; 95% confidence interval, 0.97–1.01). Diagnosis of hypertension decreased by 3% for every 1 point increase in exercise level (hazard ratio 0.97; 95% confidence interval, 0.95–1.00). There was no significant trend for dyslipidemia (hazard ratio 0.98; 95% confidence interval, 0.96–1.01) and diabetes mellitus (hazard ratio 0.97; 95% confidence interval, 0.94–1.00) (not shown in the table).

For MLDs overall in women, those who performed moderate exercise 4 or more days per week (Grade 4) were 26% (hazard ratio 1.26; 95% confidence interval, 1.12–1.41) more likely to be diagnosed with MLDs compared to those who did not exercise or about 1 day per month (grade 0). Other categories (light exercise 1 or more days per week (grade 1 and 2), moderate exercise 1–3 days per week (grade 3), and vigorous exercise 1 or more days per week (grade 5 and 6)) showed no significant difference in overall MLDs compared to those who did not exercise or about 1 day per month (grade 0). When the exercise was treated as a continuous value, there was no significant trend for MLDs overall (hazard ratio 1.01; 95% confidence interval, 0.99–1.03), for hypertension (hazard ratio 1.00; 95% confidence interval, 0.97–1.02), for dyslipidemia (hazard ratio 1.01; 95% confidence interval, 0.99–1.03) and for diabetes mellitus (hazard ratio 1.01; 95% confidence interval, 0.97–1.05) (not shown in the table).

3.6 Health Check-Up

For men, new diagnoses of MLDs were 2.3 times greater in the year of a health check-up (hazard ratio 2.30; 95% confidence interval, 2.07–2.55). Overall, there was a 16% decrease in new diagnoses of MLDs for those who experienced a health check-up in the previous year (hazard ratio 0.84; 95% confidence interval, 0.77–0.93).

For women, new diagnoses of MLDs were 2.4 times greater in the year of a health check-up (hazard ratio 2.42; 95% confidence interval, 2.20–2.66). There was no significant difference in MLDs overall depending on the experience of a health check-up in the previous year, with a decrease in hypertension and diabetes mellitus and an increase in dyslipidemia, suggesting a trade-off between the three MLDs.

3.7 Practices to Care for Health

For men, those who take care of eating amounts were 15% more likely to be diagnosed with MLDs (hazard ratio 1.15; 95% confidence interval, 1.07–1.24), with significant increases individually for dyslipidemia and diabetes mellitus, and no significant difference for hypertension. Those who brush teeth after meals were 11% less likely to be diagnosed with MLDs overall (hazard ratio 0.89; 95% confidence interval, 0.83–0.96), with individually significant reductions in hypertension and diabetes mellitus, and no significant difference in dyslipidemia.

For women, those who take care of eating amounts were 14% more likely to be diagnosed with MLDs overall (hazard ratio 1.14; 95% confidence interval, 1.06–1.23), and all of the three MLDs. Those who take a variety of foods were 8% less likely to be diagnosed with MLDs overall (hazard ratio 0.92; 95% confidence interval, 0.86–0.99), and individually there was a significant decrease in diabetes mellitus. Those who take vitamin/mineral supplements were 10% more likely to be diagnosed with MLDs (hazard ratio 1.10; 95% confidence interval, 1.02–1.18) and individually, there was a significant increase in dyslipidemia. Those who maintain proper body weight were 15% less likely to be diagnosed with MLDs overall (hazard ratio 0.85; 95% confidence interval, 0.79–0.92), and individually, all were reduced.

3.8 Others

Having a job had no significant association with MLDs diagnosis for both men and women. Those who had difficulty in daily living were more likely to be diagnosed with overall MLDs and all three MLDs for both men and women.

For men, engagement in hobbies and cultural activities had no significant association with the new diagnoses of MLDs, but those who were engaged in social participation activities were 9% more likely to be diagnosed with overall MLDs (hazard ratio 1.09; 95% confidence interval, 1.02–1.17). For women, engagement in hobbies and cultural activities had no significant associations with overall MLDs diagnosis. Engagement in social participation activities was not associated with MLDs diagnosis as well.

For men, those who cared for a relative had no significant association for diagnosing of MLDs but had a significant increase for dyslipidemia and diabetes mellitus. For women, there was an 11% increase in overall MLDs (hazard ratio 1.11; 95% confidence interval, 1.01–1.23) with no significant difference in each of the three MLDs.

4 Discussion

4.1 General Remarks

In the present study, we defined hypertension, dyslipidemia, and diabetes mellitus as mild lifestyle-related diseases (MLDs) and examined who are more (less) likely to be diagnosed with MLDs among the middle-aged and elderly persons of Japan, focusing on socio-economic status and lifestyle factors. Data from 11 years of the LSM by the MHLW of Japan were used for the analyses. For men, those who drink alcohol were more likely to be diagnosed with MLDs. Former smokers were more likely to be diagnosed with MLDs than current smokers. Men who performed light exercise four days or more per week or those who performed vigorous exercise one through three days per week were less likely to be diagnosed with MLDs than those who did not exercise or exercised about one day per month. Men who took care of eating amounts were more likely to be diagnosed with MLDs. Men who brushed their teeth after meals were less likely to be diagnosed with MLDs. For women, those who drink alcohol were less likely to be diagnosed with MLDs. Former smokers were more likely to be diagnosed with MLDs than current smokers. Women who performed moderate exercise four days or more per week were more likely to be diagnosed with MLDs than those who did not exercise or exercised about one day per month. Women who take care of their eating amount or take vitamin/mineral supplements were more likely to be diagnosed with MLDs. Women who eat a variety of foods and maintain appropriate body weight levels were less likely to be diagnosed with MLDs.

4.2 Consideration on Individual Elements

Hereinafter, we will focus on alcohol intake and smoking for which trade-offs between the three MLDs were observed. After that, we will discuss several intriguing findings, that need future explorations.

4.2.1 Alcohol Intake

Similar to previous studies, the present study suggested that alcohol intake has a positive association with hypertension, and moderate alcohol intake has a negative association with dyslipidemia and diabetes mellitus (Li et al. 2016; Roerecke et al. 2017; Vu et al. 2016). As a whole, alcohol intake has a positive association with MLDs for men, whereas moderate alcohol intake has a negative association with MLDs for women. Although the present study looks to suggest that moderate drinking is appropriate for women, careful consideration is required.

Out of the three MLDs, hypertension and dyslipidemia have no symptoms in most cases. Even in diabetes mellitus, many of those who have the disease experience no symptoms at the initial stage. Hence the three MLDs per se are not problematic unless they lead to complications and serious diseases. In reality, they are known to often lead to complication and serious diseases in particular cardiovascular diseases such as stroke and myocardial infarction. Hence, whether or not it is desirable to drink alcohol should not be determined solely based on susceptibility to MLDs, but based on its relation to the incidence of complication and serious diseases. Wood et al. (2018) found that the risk of stroke increased with increasing alcohol consumption, whereas the risk of myocardial infarction decreased. In Wood et al. (2018), in which main analyses were limited to current drinkers in order to avoid reverse causality, the group with the lowest alcohol intake (0–25 g per week) had the lowest incidence of stroke, with the incidence increasing by 14% for every 100 g more per week (hazard ratio 1.14; 95% confidence interval, 1.10–1.17). For myocardial infarction, up to a certain amount, the incidence of myocardial infarction decreased with the larger amount of alcohol intake (hazard ratio 0.94; 95% confidence interval, 0.91–0.97). Another study found that there is no ideal amount of alcohol consumption that is not harmful to health and that it is better not to drink at all (GBD 2016 Alcohol Collaborators 2018). Since strokes are more likely to occur than myocardial infarctions in the Japanese population, it seems that emphasis should be placed on stroke prevention and, even if it worsens cholesterol levels, it may be preferable for health policy to aim at guiding people away from drinking alcohol. In this sense, careful consideration should be taken regarding the results of alcohol intake in the present study.

4.2.2 Smoking

The results of the present study suggest that those who quit smoking are more likely to develop MLDs, in particular, hypertension and dyslipidemia although the length of period since they quit smoking cannot be identified from the LSM. This result may be counterintuitive, but previous studies have shown similar results (Bush et al. 2016; Takayama et al. 2018; Tamura et al. 2010), suggesting that weight gain due to smoking cessation may predispose people to hypertension, dyslipidemia, and diabetes mellitus, for which weight gain is a major risk factor (Brown et al. 2000; Colditz et al. 1995; Huang et al. 1998). Body weights of respondents were not asked in the LSM, so further analysis on this issue was not possible.

Similar to the abovementioned alcohol intake, the results of the present study regarding smoking should be interpreted carefully. Previous studies have shown that quitting smoking reduces the risk of cardiovascular diseases such as stroke and heart disease (Chen et al. 2021; Clair et al. 2013; Kim et al. 2018). Although these preventive effects were attenuated for those who gain weight after smoking cessation, the beneficial effects of quitting smoking remained to exist (Chen et al. 2021; Liu et al. 2020). In a 2019 study, heavy smokers who quit smoking have a significantly lower risk of cardiovascular disease within five years compared to those who continued smoking (Duncan et al. 2019). This indicates that the advantages of quitting smoking outweigh the disadvantages of being more likely to develop hypertension, dyslipidemia, and diabetes mellitus through weight gain.

4.2.3 Intriguing Findings Requiring Further Exploration

Amount of Food

Rather unexpectedly, both men and women who take care of eating amounts were more likely to develop MLDs. One possible explanation of this counterintuitive result is that body weight was a confounding factor; while larger body weight may lead to greater attention to food intake, larger body weight also may lead to higher susceptibility to hypertension, dyslipidemia, and diabetes mellitus. Hence, attention to food intake may be associated with the occurrence of MLDs in spite of the lack of causal relationship between them. Unfortunately, this possible explanation cannot be examined from the LSM that did not have questions on body weight. Another possible explanation is that taking care of eating amount is irrelevant to or increases the occurrence of MLDs contrary to common knowledge. Further examination based on the results of the present study is expected in order to carry out appropriate health policies (Benton and Young 2017). In particular, whether taking care of eating amount leads to an increase or decrease of MLDs should be further explored in a more rigorous manner such as randomized controlled trials.

Brushing Teeth After Meals

The results of the present study show that for men, people who brush their teeth after meals were less likely to be diagnosed with hypertension and diabetes mellitus, and for women, they were less likely to be diagnosed with diabetes mellitus. Teeth brushing had no significant association with dyslipidemia diagnosis for both men and women.

A meta-analysis of observational studies published in 2019 examined the relationship between frequency of tooth brushing and diabetes mellitus and concluded that people who brush their teeth more frequently are less likely to develop diabetes mellitus (Fu et al. 2019). In a cohort study conducted in Japan, less frequency of tooth brushing was significantly associated with diabetes mellitus in men and dyslipidemia in women, while there was no significant association between frequency of tooth brushing and hypertension (Kuwabara et al. 2017).

The results of the present study and previous studies together suggest that tooth brushing may be linked to the prevention of MLDs. However, these studies are all observational ones, and it is not possible to identify a causal relationship. Ideally, the findings of these studies should be further explored by randomized controlled trials that compare reductions in blood pressure, cholesterol, and blood glucose levels in randomized groups of people with and without tooth brushing recommendations.

Taking Vitamin/mineral Supplements

The results of the present study show that women who take vitamin/mineral supplements were more likely to be diagnosed with MLDs, and both men and women who take vitamin/mineral supplements were more likely to be diagnosed with dyslipidemia. The LSM does not ask what kind of specific vitamin/mineral is taken. Hence, specific name of the vitamin/mineral supplements cannot be identified.

Previous studies show that supplementation of zinc (Ranasinghe et al. 2015), vitamin-B3 (niacin) (McKenney 2004), and vitamin-D (Jafari et al. 2016) improve cholesterol levels, suggesting the possibility that those who take these vitamin/mineral supplements are less likely to be diagnosed with dyslipidemia. But there seems to be no adequate evidence to support vitamin C and vitamin E supplementation for dyslipidemia (Hendarto et al. 2019; Tareke and Hadgu 2021). We did not find any studies that demonstrated that vitamin/mineral supplementation increased the incidence of dyslipidemia. One possible explanation of the counterintuitive result in the present study is that cholesterol level is a confounding factor; while borderline cholesterol level may lead to taking vitamin/mineral supplements to prevent dyslipidemia, this borderline cholesterol level also may lead to higher susceptibility to dyslipidemia. However, we cannot rule out the possibility that some vitamin/mineral supplements lead to more cases of dyslipidemia and further studies are required.

4.3 Limitations of the Present Study

There are several limitations to the present study. The first limitation of the present study is its complete reliance on a particular questionnaire. Because the analysis in the present study relies entirely on the LSM, we do not have data on metrics such as blood pressure and body weight, and we may not be able to get an accurate picture of these diagnoses of MLDs from the responses. We are also concerned that some of the explanatory variables, including alcohol intake and physical exercise, leave room for subjectivity on the part of respondents and that there are problems that cannot be quantified by a questionnaire. It is desirable to construct a panel (longitudinal) dataset that combines the LSM or similar surveys with health examination data, which will elucidate the associations of health markers such as blood pressure and body weight with variables related to socio-economic status and lifestyles more clearly.

The second limitation of the present study is the possibility of bias due to non-response. In the LSM on which the present study's analyses rely, the number of respondents in 2016 was roughly two thirds of that in 2005, indicating a substantial number of dropouts. Even when responses were received, there were still unanswered questions on individual questions, with a particularly large number of unanswered questions on income and assets. For this reason, we did not include these variables in the analyses, but some studies have suggested that these variables affect MLDs (Bird et al. 2015) and including income and assets as explanatory variables may change the results of the analysis.

The third limitation of the present study is that the analysis in the present study is not based on randomized controlled trials, and therefore no causal relationships can be identified. Although interesting results were obtained with regard to eating amount, tooth brushing, etc., they cannot be definitive and would ideally need to be validated by randomized controlled trials.

5 Conclusion

In the present study, we explored who are more (less) likely to be diagnosed with any, some or all of the mild lifestyle-related diseases (MLDs), here defined as hypertension, dyslipidemia, and diabetes mellitus among middle-aged and elderly persons. Our findings showed some intriguing points to be explored in future studies. For example, those who take care of eating amount were more likely to be newly diagnosed with MLDs and those who brush teeth after meals were less likely to be newly diagnosed with MLDs. These relationships are just associations at this stage.

Causal relationships should be examined through randomized controlled trials or other rigorous methods (Figs. 1 and 2).

References

Allison PD (1982) Discrete-time methods for the analysis of event histories. Sociol Methodol 13:61–98. https://doi.org/10.2307/270718

Benton D, Young HA (2017) Reducing calorie intake may not help you lose body weight. Perspect Psychol Sci 12(5):703–714. https://doi.org/10.1177/1745691617690878

Bird Y, Lemstra M, Rogers M, Moraros J (2015) The relationship between socioeconomic status/income and prevalence of diabetes and associated conditions: a cross-sectional population-based study in Saskatchewan, Canada. Int Equity Health 14(1):93. https://doi.org/10.1186/s12939-015-0237-0

Brown CD, Higgins M, Donato KA, Rohde FC, Garrison R, Obarzanek E, Ernst ND, Horan M (2000) Body mass index and the prevalence of hypertension and dyslipidemia. Obesity Res 8(9):605–619. https://doi.org/10.1038/oby.2000.79

Bush T, Lovejoy JC, Deprey M, Carpenter KM (2016) The effect of tobacco cessation on weight gain, obesity, and diabetes risk. Obesity (silver Spring) 24(9):1834–1841. https://doi.org/10.1002/oby.21582

Chen S, Kawasaki Y, Hu H, Kuwahara K, Yamamoto M, Uehara A, Honda T, Yamamoto S, Nakagawa T, Miyamoto T, Okazaki H, Dohi S (2021) Smoking cessation, weight gain, and the trajectory of estimated risk of coronary heart disease: 8-year follow-up from a prospective cohort study. Nicotine Tob Res 23(1):85–91. https://doi.org/10.1093/ntr/ntz165

Clair C, Rigotti NA, Porneala B, Fox CS, D'Agostino RB, Pencina MJ, Meigs JB (2013) Association of smoking cessation and weight change with cardiovascular disease among adults with and without diabetes. JAMA 309(10):1014–1021. https://doi.org/10.1001/jama.2013.1644

Colberg SR, Sigal RJ, Yardley JE, Riddell MC, Dunstan DW, Dempsey PC, Horton ES, Castorino K, Tate DF (2016) Physical activity/exercise and diabetes: a position statement of the american diabetes association. Diabetes Care 39(11):2065–2079. https://doi.org/10.2337/dc16-1728

Colditz GA, Willett WC, Rotnitzky A, Manson JE (1995) Weight gain as a risk factor for clinical diabetes mellitus in women. Ann Intern Med 122(7):481–486. https://doi.org/10.7326/0003-4819-122-7-199504010-00001

Duncan MS, Freiberg MS, Greevy RA Jr, Kundu S, Vasan RS, Tindle HA (2019) Association of smoking cessation with subsequent risk of cardiovascular disease. JAMA 322(7):642–650. https://doi.org/10.1001/jama.2019.10298

Fu W, Lv C, Zou L, Song F, Zeng X, Wang C, Yan S, Gan Y, Chen F, Lu Z, Cao S (2019) Meta-analysis on the association between the frequency of tooth brushing and diabetes mellitus risk. Diab Metab Res Rev 35(5):e3141. https://doi.org/10.1002/dmrr.3141

GBD (2016) Alcohol Collaborators (2018) Alcohol use and burden for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 392(10152):1015–1035. https://doi.org/10.1016/s0140-6736(18)31310-2

Gordon B, Chen S, Durstine JL (2016) The effects of exercise training on the traditional lipid profile and beyond. Trans J Am Coll Sports Med 1(18):159–164. https://doi.org/10.1249/tjx.0000000000000023

Hagberg JM, Park J-J, Brown MD (2000) The role of exercise training in the treatment of hypertension. Sports Med 30(3):193–206. https://doi.org/10.2165/00007256-200030030-00004

Hendarto A, Alhadar AK, Sjarif DR (2019) The effect of vitamin E supplementation on lipid profiles and adiponectin levels in obese adolescents: a randomized controlled trial. Acta Med Indones 51(2):110–116

Huang Z, Willett WC, Manson JE, Rosner B, Stampfer MJ, Speizer FE, Colditz GA (1998) Body weight, weight change, and risk for hypertension in women. Ann Intern Med 128(2):81–88. https://doi.org/10.7326/0003-4819-128-2-199801150-00001

Jafari T, Fallah AA, Barani A (2016) Effects of vitamin D on serum lipid profile in patients with type 2 diabetes: a meta-analysis of randomized controlled trials. Clin Nutr 35(6):1259–1268. https://doi.org/10.1016/j.clnu.2016.03.001

Kim K, Park SM, Lee K (2018) Weight gain after smoking cessation does not modify its protective effect on myocardial infarction and stroke: evidence from a cohort study of men. Eur Heart J 39(17):1523–1531. https://doi.org/10.1093/eurheartj/ehx761

Kuwabara M, Motoki Y, Sato H, Fujii M, Ichiura K, Kuwabara K, Nakamura Y (2017) Low frequency of toothbrushing practices is an independent risk factor for diabetes mellitus in male and dyslipidemia in female: a large-scale, 5-year cohort study in Japan. J Cardiol 70(2):107–112. https://doi.org/10.1016/j.jjcc.2016.10.008

Li X-H, Yu F-f, Zhou Y-H, He J (2016) Association between alcohol consumption and the risk of incident type 2 diabetes: a systematic review and dose-response meta-analysis. Am J Clin Nutr 103(3):818–829. https://doi.org/10.3945/ajcn.115.114389

Liu G, Hu Y, Zong G, Pan A, Manson JE, Rexrode KM, Rimm EB, Hu FB, Sun Q (2020) Smoking cessation and weight change in relation to cardiovascular disease incidence and mortality in people with type 2 diabetes: a population-based cohort study. Lancet Diab Endocrinol 8(2):125–133. https://doi.org/10.1016/s2213-8587(19)30413-9

McKenney J (2004) New perspectives on the use of niacin in the treatment of lipid disorders. Arch Intern Med 164(7):697–705. https://doi.org/10.1001/archinte.164.7.697

Miura K, Nagai M, Ohkubo T (2013) Epidemiology of hypertension in Japan: where are we now? Circ J 77(9):2226–2231. https://doi.org/10.1253/circj.CJ-13-0847

Oshio T, Kan M (2019) Educational level as a predictor of the incidences of non-communicable diseases among middle-aged Japanese: a hazards-model analysis. BMC Public Health 19(1):852. https://doi.org/10.1186/s12889-019-7182-6

Oshio T, Kan M (2019) Preventive impact of social participation on the onset of non-communicable diseases among middle-aged adults: a 10-wave hazards-model analysis in Japan. Prev Med 118:272–278. https://doi.org/10.1016/j.ypmed.2018.11.016

Ranasinghe P, Wathurapatha WS, Ishara MH, Jayawardana R, Galappatthy P, Katulanda P, Constantine GR (2015) Effects of Zinc supplementation on serum lipids: a systematic review and meta-analysis. Nutr Metab (lond) 12:26. https://doi.org/10.1186/s12986-015-0023-4

Roerecke M, Kaczorowski J, Tobe SW, Gmel G, Hasan OSM, Rehm J (2017) The effect of a reduction in alcohol consumption on blood pressure: a systematic review and meta-analysis. Lancet Public Health 2(2):e108–e120. https://doi.org/10.1016/s2468-2667(17)30003-8

Saito E, Inoue M, Sawada N, Charvat H, Shimazu T, Yamaji T, Iwasaki M, Sasazuki S, Mizoue T, Iso H, Tsugane S (2018) Impact of alcohol intake and drinking patterns on mortality from all causes and major causes of death in a Japanese population. J Epidemiol 28(3):140–148. https://doi.org/10.2188/jea.JE20160200

Singer JD, Willett JB (1993) It's about time: using discrete-time survival analysis to study duration and the timing of events. J Educ Stat 18(2):155–195. https://doi.org/10.3102/10769986018002155

Singer JD, Willett JB (2003) Applied longitudinal data analysis: modeling change and event occurrence. Oxford University Press, New york

Takayama S, Takase H, Tanaka T, Sugiura T, Ohte N, Dohi Y (2018) Smoking cessation without educational instruction could promote the development of metabolic syndrome. J Atheroscler Thromb 25(1):90–97. https://doi.org/10.5551/jat.40063

Tamura U, Tanaka T, Okamura T, Kadowaki T, Yamato H, Tanaka H, Nakamura M, Okayama A, Ueshima H, Yamagata Z, HIPOP-OHP research group (2010) Changes in weight, cardiovascular risk factors and estimated risk of coronary heart disease following smoking cessation in Japanese male workers: HIPOP-OHP study. J Atherosclerosis Thromb 17(1):12–20. https://doi.org/10.5551/jat.1800

Tareke AA, Hadgu AA (2021) The effect of vitamin C supplementation on lipid profile of type 2 diabetic patients: a systematic review and meta-analysis of clinical trials. Diabetol Metab Syndr 13(1):24. https://doi.org/10.1186/s13098-021-00640-9

Vu KN, Ballantyne CM, Hoogeveen RC, Nambi V, Volcik KA, Boerwinkle E, Morrison AC (2016) Causal role of alcohol consumption in an improved lipid profile: the atherosclerosis risk in communities (ARIC) study. PLoS One 11(2):e0148765. https://doi.org/10.1371/journal.pone.0148765

Wood AM, Kaptoge S, Butterworth AS, Willeit P, Warnakula S, Bolton T, Paige E, Paul DS, Sweeting M, Burgess S, Bell S, Danesh J (2018) Risk thresholds for alcohol consumption: combined analysis of individual-participant data for 599 912 current drinkers in 83 prospective studies. The Lancet 391(10129):1513–1523. https://doi.org/10.1016/S0140-6736(18)30134-X

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Chapter 13
Life and Workplace Satisfaction and Behaviour Change Ability—An Empirical Study in Japan

Kazuo Nishimura and Tadashi Yagi

Abstract This paper analyzes the attributes that would cause behaviour change based on responses to questions about behaviour change, examines how satisfaction with their life is associated with the respondents' behaviour change, and determines whether there would be any difference in their levels of satisfaction between those who can change their behaviour and those who cannot. Behaviour change has been studied in diverse fields and has gradually been attracting attention. However, we have yet to see much research that discusses the dependent attributes of people's behaviour change or to what extent behaviour change influences people's sense of satisfaction in life. In this research, we conducted a factor analysis of responses to surveys to identify behaviour change and examined the dependency of the obtained factors on age, sex, positive thinking, and the degree of self-determination. We also analyzed how behaviour change is associated with life and workplace satisfaction. Our findings revealed that sex, positive thinking, and the degree of self-determination affected all three behaviour change factors. Positive thinking had a positive effect on all three factors, while male dummy had a negative impact on all three factors. The self-determination index positively affected persistence in learning and malleability, but it had a negative impact on receptivity. Age affected only malleability, while male dummy had a positive impact. We have also examined how a person's ability to change their behaviour affected their satisfaction level in their life and workplace. Our findings showed that malleability, among the behaviour change abilities, played an important role in enhancing the satisfaction level in a person's life, and demonstrated a statistically significant positive effect on health, stress, income, and relationship with their partner. With regard to the satisfaction level in the workplace, the behaviour change abilities (persistence in learning, malleability, receptivity) had common effects on satisfaction with work environment, job discretion, peers at work, perception of doing a good job, their immediate supervisor, and job security; persistence in learning and malleability had a positive effect, whereas receptivity had a

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negative impact. On all these items, the strongest impact was made by persistence in learning, and a relatively weak effect was made by receptivity.

Keywords Behavior change · Persistence in learning · Malleability · Receptivity · Life satisfaction · Workplace satisfaction

1 Introduction

The term "behaviour change" was originally used in the medical field, where it referred to a change in a patient's behaviour prompted by a medical professional. The prompting by the medical professional, however, is a trigger, not an enforcement. Unless patients accept the guidance given by the medical professional and change their way of thinking, their behaviour will not change. The spontaneity of behaviour change can be a concept applicable to a broad range of fields. Thus, we define the term "behaviour change" as "any spontaneous change in a person's behaviour prompted by a trigger of some sort", which we use to analyze a more universal range of behaviour changes. In economics, for instance, "behaviour change" may include the impact of advertisement on consumer behaviour or a change in consumer behaviour caused by a change in government policy such as an increase in consumption tax.

The feasibility of behaviour change may differ depending on individuals. For example, among those who wish to stop smoking for health reasons, some can while others cannot.

This chapter analyzes the attributes that would cause behaviour change based on responses to questions about behaviour change, examines how satisfaction with their life is associated with the respondents' behaviour change, and determines whether there would be any difference in their levels of satisfaction between those who can change their behaviour and those who cannot.

Studies on behaviour change have mainly been conducted on subjects such as control of drug use and smoking, elimination of obesity, and prevention of lifestyle-related diseases. Research in behavioural economics uses the concept of hyperbolic discounts, which explains that people's inability to change their behaviour stems from their desire for immediate rewards over higher-value delayed rewards (Fudenberg and Levine 2006; Gruber and Köszegi 2001; O'Donoghue and Rabin 1999).

In the past, behaviour change has been explained by the goal-setting theory (Edwin 1968), which argues that setting a clear goal rather than an ambiguous one and a difficult goal rather than an easy one, will bring higher motivation and better results. The transtheoretical model of behaviour change (see Prochaska et al. 1992) also discusses that it is necessary to make an appropriate approach for each of the five stages (that is, precontemplation, contemplation, preparation for action, action, and maintenance) to promote behaviour change.

More recent theories on behaviour change include the social-psychological behavioral theory (Goffman 2006) and the choice architecture theory (Loewenstein et al. 2015; Thaler and Sunstein 2008; Vlaev et al. 2016). The former tries to understand behaviour change in the context of social relationships, whereas the latter provides a method using nudges to change people's behaviour in a predictable manner without intervention.

As explained above, behaviour change has been studied in diverse fields and has gradually been attracting attention. However, we have yet to see much research that discusses the dependent attributes of people's behaviour change or to what extent behaviour change influences people's sense of satisfaction in life.

In this research, we conducted a factor analysis of responses to surveys to identify behaviour change and examined the dependency of the obtained factors on age, sex, positive thinking, and the degree of self-determination. We also analyzed how behaviour change is associated with life and workplace satisfaction.

Section 2 of this chapter gives an outline of the survey data. In Sect. 3, we extracted the factors that constitute behaviour change by factor analysis and, in Sect. 4, we analyzed relationships between the ability to change behaviour and positive thinking, the degree of self-determination, and other items. In Sect. 5, we analyzed how behaviour change ability is related to the levels of life and workplace satisfaction. Section 6 summarizes our conclusion.

2 Outline of the Data

The data used in this study were obtained from the "Internet Survey on Living Environment and Happiness" and the "Additional Survey" to the "Internet Survey on Living Environment and Happiness" conducted through Rakuten Insight (former Rakuten Research) as part of the "Fundamental Research for Economic Growth and Productivity Improvement in Japan" at the Research Institute of Economy, Trade and Industry. The first survey was conducted from February 8, 2018, to February 13, 2018, and the additional survey from August 23, 2018, to September 3, 2018. These surveys were conducted on male and female individuals aged 20–69 years across Japan by allocating the number of samples to be collected according to sex, age, and the population composition of each prefecture.

In the first survey, the number of surveys delivered was 933,329; 33,598 responses were collected, for a response rate of 3.6%. In the additional survey, the number of surveys delivered was 20,005, and 16,000 responses were collected, for a response rate of 80%. We checked the collected samples for inconsistency and other faults and extracted only the data with high reliability. As a consequence, the number of collected samples used in our analysis totalled 20,005.

Data characteristics are summarized as follows. The sample size of the data set used in this study was 20,005, of which 3335 did not respond to the question about annual household income. Accordingly, the number of effective observations used in the analysis was 16,670. The number of non-responses to the question about annual personal income was 2359, resulting in 17,646 effective observations. The sample size, however, was reduced to 16,000, if we used the questions to which responses were obtained in the additional survey. The distribution by sex was 50.2% males and 49.8% females, indicating a nearly equal number of male and female respondents.

3 Extraction of Behaviour Change Variables

In the additional survey, we asked questions about the extent of actions that the respondent would take with regard to behaviour change. We then extracted attributes that characterize behaviour change using principal component analysis based on the responses given using a five-point Likert scale.

Table 1 shows that three factors with eigenvalues greater than 1 are extracted by factor analysis (principal components method). It indicates that the first principal factor has the strongest explanatory power.

In Table 2, the questions that are closely related to the same principal factors are arranged together. The interpretation of the principal factors is given from the questions belonging to the same principal factors. Since the first principal factor has a strong correlation with the four questions asking the respondents whether they can persistently study or can properly learn if required at work, it can be interpreted as "persistence in learning". The second principal factor has a strong correlation with the four questions asking the respondents whether they can voluntarily change their behaviour or can voluntarily take actions. This ability to take action has been named "malleability". Meanwhile, the third principal factor has been named "receptivity", since it has a strong correlation with the three questions asking the respondents whether they accept external prompting such as an influence of advertisements to take actions. In this chapter, accordingly, we interpret each of the extracted principal factors as "persistence in learning", "malleability", and "receptivity".

Figure 1 shows the size of each of the three principal factors that constitute behaviour change ability by sex. Males exhibit higher persistence in learning, whereas females score higher in malleability. Receptivity is significantly higher for females.

4 Effects of the Degree of Self-Determination and Positive Thinking on Behaviour Change Ability

Since persistence in learning, for example, is considered to have a strong correlation with the conscientiousness of respondents, we can assume that the ability to change behaviour may be affected to some extent by the personality of respondents. Therefore, we included the Big Five personality traits, that is, conscientiousness, openness to experience, neuroticism, extraversion, and disagreeableness in the explanatory variable. We conducted a multiple regression analysis to identify the impact of attribute information such as personality factors, age, and sex, as well as of

Table 1 Results of factor analysis (principal component methods)

Sums of squared loadings									
Factor	Initial eigenvalues			Sums of squared loadings after extraction			Sums of squared loadings after rotation		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.545	37.874	37.874	4.545	37.874	37.874	3.441	28.677	28.677
2	1.532	12.764	50.639	1.532	12.764	50.639	2.071	17.262	45.939
3	1.05	8.753	59.391	1.05	8.753	59.391	1.614	13.452	59.391
4	0.87	7.247	66.638						

Table 2 Interpretation of principal factors (correlation with questions and factors)

Question	Persistence (in learning)	Malleability	Receptivity
I can persistently study if I need to understand mathematical formulas for work, or other purposes	*0.901*	0.144	0.093
I can persistently study if I have to read mathematical books outside of your area of expertise for work or other reasons	*0.894*	0.142	0.098
I can persist in learning the manuals I need to learn on the job	*0.869*	0.191	0.123
I can learn English and other languages when I need to learn them for work or other reasons	*0.692*	0.165	0.284
If required to get up early in the morning for work or other reasons, I can go to bed early the night before	*0.605*	0.353	–0.001
I can change my habits if I judge them to be bad	0.273	*0.682*	0.065
I do things that I hear are good for my health	0.122	*0.649*	0.358
I use stairs instead of escalators at railway stations	0.073	*0.649*	0.018
If a special tax is to be imposed on one of my luxury items (e.g. alcohol or cigarettes) on the grounds that it is bad for health, and the price increases by 20%, I will reduce my purchase of the item considerably	0.154	*0.594*	0.129
I tend to buy goods influenced by advertisements	–0.078	–0.021	*0.805*
I read books recommended by my friends	0.299	0.14	*0.671*
I will make a donation if requested to do so for solving starvation problems in developing countries	0.125	0.402	*0.503*

Note Highlighted cells indicate the questions those have strong correlation with factors

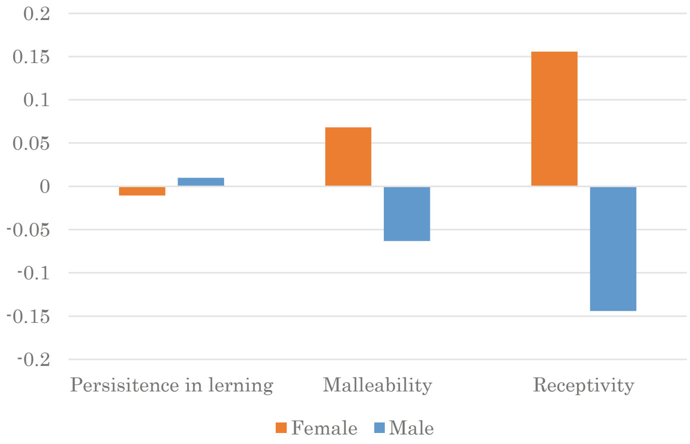

Fig. 1 Difference in behaviour change ability between males and females

positive thinking and the degree of self-determination on the formation of the three behaviour change abilities.

Positive thinking was found as a factor that contributed to generating a sense of happiness and that the degree of self-determination was an important factor for determining a sense of happiness in our earlier survey on happiness (Nishimura and Yagi 2019).

The degree of positive thinking was determined by extracting the factors via factor analysis, adopting the principal factor method, and using 18 questions selected from the list of questions used by Hills and Argyle (2002). Table 3 shows the explanatory power of the factors extracted by factor analysis in terms of percentage of variance and cumulative percentage of initial eigenvalues.

In the principal factor analysis, the percentage of variance was equal to the cumulative percentage, since there was only one factor. Table 4 gives the correlation coefficients between the responses to each of the 18 questions and the factor.

In this survey, we asked the questions: "Who decided on the high school you would attend?" and "Who decided on the university you would attend?" The respondents answered these questions by selecting the most appropriate answer from five choices: (1) I followed the suggestions of people around me, although the school was not my choice at all; (2) I followed the suggestions of people around me, although I was not very willing to attend that school; (3) I am not sure; (4) I decided as I wished, to some extent; and (5) I decided as I wished. From those who did not go on to university, we also obtained responses as to the degree of self-determination when they decided to go to vocational school or junior college and when they decided not to go to university. The average scores on a 5-point scale were: 4.35 for those who did not graduate from university, 3.85 for graduates of low-difficulty universities, 4.09 for graduates of medium-difficulty universities, and 4.41 for graduates of high-difficulty

Table 3 Extraction sums of squared loadings

Factor	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.974	34.392	34.392	9.449	32.584	32.584	6.593	22.735	22.735

Table 4 Factor matrix after rotation

	Positive thinking
I can have a positive influence on things	0.7
I always encourage other people	0.688
I always work on things earnestly	0.684
I can enjoy almost anything	0.66
I can see beautiful elements in things	0.657
I am very active	0.656
Life is wonderful	0.647
Life is very fruitful	0.645
I feel I can challenge anything	0.63
I am kind to almost everybody	0.619
I laugh a lot	0.583
I am very happy	0.531
I am quite satisfied with my life	0.51
I can find time to do what I want to do	0.449
I am often feeling good and in a merry mood	0.444
It is not difficult for me to make a decision	0.433
I have an agile mind and am very careful	0.421
I am very much interested in other people	0.406

universities. Those who did not graduate from university showed that their degree of self-determination was similar to the high degree of difficulty they experienced.

We also asked the question: "Did you decide on your first job by yourself? Please choose the one that best applies to your case." The respondents answered this question by selecting one answer from the following six choices: (1) I followed the suggestions of people around me, although it was not my choice at all; (2) I followed the suggestions of people around me, although I was not very willing to join the company; (3) I am not sure; (4) I decided as I wished, to some extent; (5) I decided as I wished; and (6) I have never been employed. We dealt with those who chose answer (6) as missing values.

We conducted a factor analysis of the questions about self-determination at three stages: "advancing from junior high school to high school", "going to university from high school", and "first employment" to create self-determination factors. We call the factor score (the value computed by the factor analysis) the self-determination index.

Table 5 shows the results of a multivariable regression analysis of the effects of personality factors, age, sex, positive thinking, and the degree of self-determination on behaviour change ability. Figure 2 shows to what extent the ability of behaviour change is explained by positive thinking, the degree of self-determination, and age when effects of personality factors are deleted.

Table 5 Analysis of factors determining behaviour change ability (standardized coefficient)

	Persistence in learning		Malleability		Receptivity	
	Standard coefficient	p-value	Standard coefficient	p-value	Standard coefficient	p-value
Conscientiousness	0.187	0.000	0.062	0.003	–0.092	0.000
Openness to experience	0.09	0.000	0.032	0.079	0.043	0.017
Neuroticism	–0.145	0.000	–0.009	0.553	0.109	0.000
Extraversion	0.006	0.732	0.01	0.603	0.047	0.012
Disagreeableness	–0.035	0.021	–0.082	0.000	0.005	0.721
Positive thinking	0.071	0.005	0.137	0.000	0.244	0.000
Self-determination index	0.098	0.000	0.045	0.003	–0.045	0.003
Age	–0.015	0.326	0.116	0.000	–0.01	0.509
Male dummy	–0.028	0.06	–0.042	0.007	–0.117	0.000

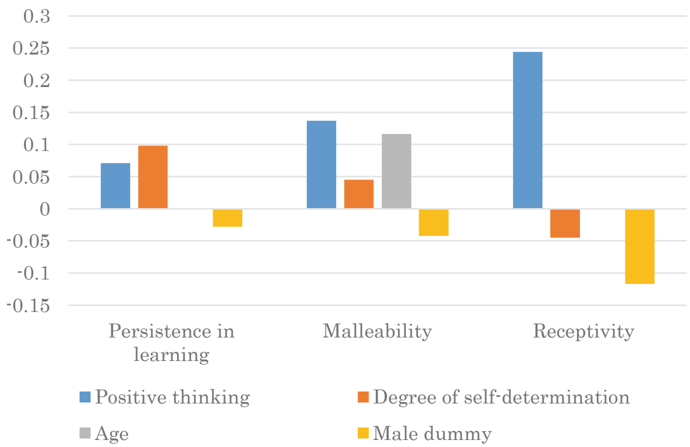

Fig. 2 Analysis of factors determining behaviour change ability

Factors that affected persistence in learning were positive thinking, the degree of self-determination, and the male dummy variable (hereafter referred to as "male dummy"). While positive thinking and the degree of self-determination had a positive effect, the male dummy variable had a negative impact. The intensity of the effect in descending order was: self-determination index, positive thinking, and male dummy variable.

Meanwhile, the factors that affected malleability were positive thinking, the degree of self-determination, age, and male dummy variable. Positive thinking, the degree of self-determination, and age had a positive impact, whereas male dummy variable had a negative impact. The intensity of the effect in descending order was: positive thinking, age, degree of self-determination, and male dummy variable. Factors that affected receptivity, on the other hand, were positive thinking, the degree of self-determination, and male dummy. Positive thinking had a positive effect, while the degree of self-determination and male dummy had a negative impact. The intensity of the effect in descending order was: positive thinking, male dummy variable, and degree of self-determination.

Positive thinking affected all three abilities of behaviour change in a positive way, showing an overwhelmingly strong impact, especially on receptivity. This suggests that those with a positive thinking attitude flexibly accept advice from others and that they are willing to change their behavioural patterns.

While the degree of self-determination also affected all three behaviour change abilities, it had a negative impact solely on receptivity. This suggests that those with a high degree of self-determination are unwilling to take advice from others.

Age had an effect only on malleability, which indicates that the possibility to change behaviour patterns increases with age.

Male dummy negatively affected all three behaviour change abilities, suggesting that females have a higher ability to change their behaviour than males.

5 Behaviour Change, Health, and Satisfaction in Life and the Workplace

5.1 Survey Items

In this survey, we asked about health conditions, stress, satisfaction in life, and satisfaction in the workplace using the questions below:

i. How are your current health conditions? Choices for answer: (1) bad, (2) fairly bad, (3) neither bad nor good, (4) fairly good, and (5) good.
ii. How do you rate the overall level of stress you feel in your daily life? Please select the option closest to your level of stress from the following numbers (0) to (10). Choices for answer: (0) no stress and (10) Feeling severe stress.
iii. To what extent are you satisfied with the following aspects of your life? Item 1: household income/revenue; Item 2: household assets/savings; Item 3: relationship with your spouse (husband or wife) or boyfriend/girlfriend. Choices for answer: (1) dissatisfied, (2) fairly dissatisfied, (3) neither dissatisfied nor satisfied, (4) fairly satisfied, and (5) satisfied.
iv. To what extent are you satisfied with your current work in terms of the following items? Item 1: work environment; Item 2: discretion in ways to carry out your work; Item 3: co-workers; Item 4: recognition of doing a good job; Item 5: your immediate superior; Item 6: responsibility given to you; Item 7: your wage/salary; Item 8: opportunities for you to use your abilities; Item 9: relationships between the management and employees; Item 10: opportunities for

your promotion; Item 11: the way your organization is operated; Item 12: attention paid to your proposals; Item 13: your working hours; and Item 14: your job security. Choices for answer: (1) dissatisfied, (2) fairly dissatisfied, (3) neither dissatisfied nor satisfied, (4) fairly satisfied, and (5) satisfied

Based on the answers to these questions, we aimed to clarify how the degree of behaviour change ability affects the satisfaction level in a person's health, life, and workplace, using a multiple regression analysis. This analysis included the Big Five personality traits as explanatory variables to eliminate personality factors.

5.2 *Effects on Health and Satisfaction in Life*

As shown in Table 6, malleability had the strongest impact other than age on health conditions. This suggests that those who can change their life habits as required for achieving better health are able to maintain their good health.

Figure 3 shows behavior change abilities and satisfaction with health and life. With regard to stress, our findings showed that stress decreases with age and that males felt less stress than females did. Higher malleability led to less stress and higher receptivity caused more stress. These findings suggest that those who can think flexibly and change their behaviour are able to reduce stress and that those who are liable to be influenced by others feel more stress.

All three behaviour change abilities positively affected the level of satisfaction with household income; those who had higher behaviour change abilities showed a higher level of satisfaction with their income.

With respect to satisfaction with their partner, while receptivity among the behaviour change abilities had no effect on it, persistence in learning and malleability did have an impact. This indicates that those who understand their partner and can change their behaviour to improve their relationship feel a high level of satisfaction with their partner. Our findings also suggest that those who are liable to be influenced by others may increase their dissatisfaction with their partner, failing to feel satisfied with their partner

5.3 *Effects on Satisfaction in Workplace*

Tables 7 and 8, and Figs. 4 and 5 show the effects of behaviour change abilities on a person's satisfaction in the workplace. There is a common impact of ability to change behaviours on satisfaction with the work environment, job discretion, peers at work, perception of doing a good job, immediate supervisors, and job security, with persistence in learning and malleability having a positive impact and receptivity having a negative effect. On each of these items, the strongest impact was made by persistence in learning, and a relatively weak effect by receptivity. This indicates

Table 6 Multiple regression analysis of effects on health and satisfaction in life Results (standardized coefficient)

	Current health conditions		Level of stress		Satisfaction with household income		Satisfaction with the partner	
	Standardized coefficient	p-value	Standardized coefficient	p-value	Standardized coefficient	p-value	Standardized coefficient	p-value
Age	–0.136	0.000	–0.108	0.000	0.031	0.000	0.038	0.000
Male dummy	–0.009	0.218	–0.058	0.000	–0.019	0.015	0.066	0.000
Conscientiousness	0.119	0.000	–0.016	0.030	0.052	0.000	0.082	0.000
Openness to experience	0.021	0.006	–0.077	0.000	0.022	0.006	0.015	0.083
Neuroticism	–0.164	0.000	0.204	0.000	–0.127	0.000	–0.050	0.000
Extraversion	0.233	0.000	–0.206	0.000	0.131	0.000	0.156	0.000
Disagreeableness	–0.135	0.000	0.209	0.000	–0.057	0.000	–0.118	0.000
Persistence in learning	0.022	0.006	–0.002	0.820	0.048	0.000	0.057	0.000
Malleability	0.075	0.000	–0.018	0.016	0.034	0.000	0.053	0.000
Receptivity	–0.005	0.477	0.016	0.029	0.049	0.000	0.003	0.718

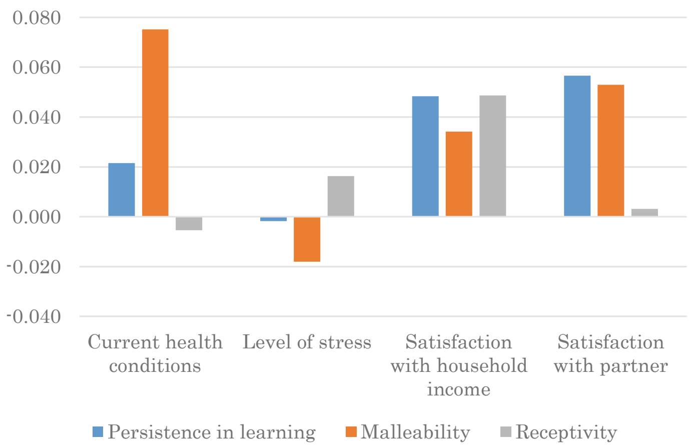

Fig. 3 Behaviour change abilities and satisfaction with health and life

that those who have higher persistence and can transform their behaviour in the right direction have a higher level of satisfaction in the workplace and that those who are more liable to be influenced by others have a lower level of satisfaction.

6 Conclusion

In this study, we broke down behaviour change into three factors (that is, persistence in learning, malleability, and receptivity) based on the data from surveys, to analyze the ability of people to change their behaviour. We then studied how each of these factors is dependent on sex, age, positive thinking, and the degree of self-determination. Our findings revealed that sex, positive thinking, and the degree of self-determination affected all three behaviour change factors. Positive thinking had a positive effect on all three factors, while male dummy had a negative impact on all three factors. The self-determination index positively affected persistence in learning and malleability, but it had a negative impact on receptivity. Age affected only malleability, while male dummy had a positive impact.

We have also examined how a person's ability to change their behaviour affected their satisfaction level in their life and workplace. Our findings showed that malleability, among the behavior change abilities, played an important role in enhancing the satisfaction level in a person's life, and demonstrated a statistically significant positive effect on health, stress, income, and relationship with their partner. With regard to the satisfaction level in the workplace, the behaviour change abilities (persistence in learning, malleability, receptivity) had common effects on satisfaction with work environment, job discretion, peers at work, perception of doing a good job, their immediate supervisor, and job security; persistence in learning and malleability

Table 7 Results of multiple regression analysis of effects on satisfaction in the workplace (1) (standardized coefficient)

	The work environment		Job discretion		Peers at work		Perception of doing a good job		Immediate supervisors	
	Standardized coefficient	p-value	Standardized coefficient	p-value	Standardized coefficient	p-value	Standardized coefficient	p-value	Standardized coefficient	p-value
Age	0.040	0.000	0.081	0.000	–0.002	0.832	0.065	0.000	–0.033	0.001
Male dummy	–0.006	0.532	–0.006	0.549	–0.019	0.044	–0.029	0.001	0.012	0.208
Conscientiousness	0.113	0.000	0.146	0.000	0.105	0.000	0.189	0.000	0.079	0.000
Openness to experience	0.026	0.006	0.067	0.000	0.030	0.001	0.087	0.000	0.039	0.000
Neuroticism	–0.053	0.000	–0.054	0.000	0.009	0.357	–0.080	0.000	–0.017	0.076
Extraversion	0.135	0.000	0.163	0.000	0.210	0.000	0.225	0.000	0.146	0.000
Disagreeableness	–0.080	0.000	–0.060	0.000	–0.143	0.000	–0.120	0.000	–0.100	0.000
Persistence in learning	0.077	0.000	0.080	0.000	0.072	0.000	0.070	0.000	0.072	0.000
Malleability	0.043	0.000	0.031	0.001	0.049	0.000	0.037	0.000	0.033	0.000
Receptivity	–0.007	0.444	–0.031	0.001	–0.023	0.013	–0.016	0.078	–0.011	0.234

Table 8 Results of multiple regression analysis of the effects on satisfaction in the workplace (2) (standardized coefficient)

	Given responsibility		Wage/Salary		Opportunities to use abilities		Opportunities for promotion		Job security	
	Standardized coefficient	p-value	Standardized coefficient	p-value	Standardized coefficient	p-value	Standardized coefficient	p-value	Standardized coefficient	p-value
Age	0.048	0.000	0.035	0.000	0.056	0.000	–0.020	0.037	–0.052	0.000
Male dummy	–0.010	0.271	–0.015	0.110	–0.015	0.111	0.047	0.000	0.074	0.000
Conscientiousness	0.162	0.000	0.029	0.003	0.128	0.000	0.036	0.000	0.103	0.000
Openness to experience	0.057	0.000	0.016	0.106	0.036	0.000	0.032	0.001	–0.028	0.003
Neuroticism	–0.060	0.000	–0.079	0.000	–0.055	0.000	–0.069	0.000	–0.031	0.001
Extraversion	0.171	0.000	0.117	0.000	0.157	0.000	0.118	0.000	0.137	0.000
Disagreeableness	–0.102	0.000	–0.049	0.000	–0.086	0.000	–0.064	0.000	–0.078	0.000
Persistence in learning	0.090	0.000	0.053	0.000	0.068	0.000	0.039	0.000	0.071	0.000
Malleability	0.046	0.000	0.016	0.091	0.032	0.001	0.017	0.070	0.051	0.000
Receptivity	–0.020	0.033	0.026	0.006	–0.028	0.002	0.007	0.442	–0.010	0.297

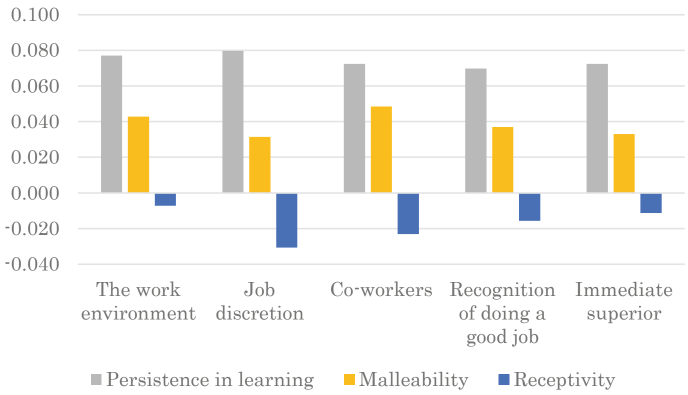

Fig. 4 Behaviour change abilities and satisfaction in the workplace (1)

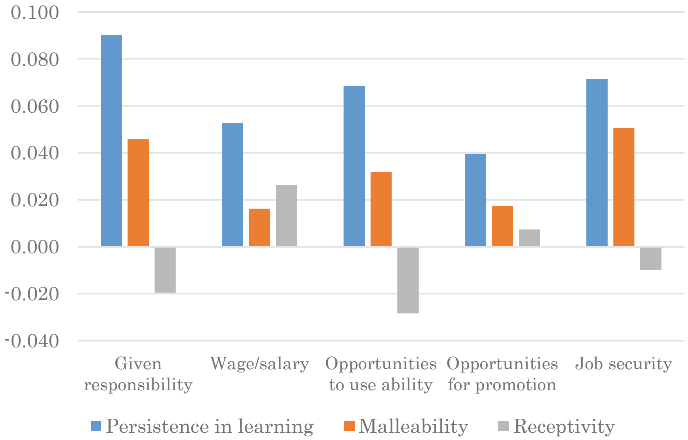

Fig. 5 Behaviour change abilities and satisfaction in the workplace (2)

had a positive effect, whereas receptivity had a negative impact. On all these items, the strongest impact was made by persistence in learning, and a relatively weak effect was made by receptivity.

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References

Edwin LA (1968) Toward a theory of task motivation and incentives. Organ Behav Hum Perform 3(2):157–189

Fudenberg D, Levine DK (2006) A dual-self model of impulse control. Am Econ Rev 96(5):1449–1476

Goffman E (2006) The presentation of self in everyday life. A dramaturgical sourcebook anchor. Palatine Illinois

Gruber J, Köszegi B (2001) Is addiction rational? theory and evidence. Q J Econ 116(4):1261–1303

Hills P, Argyle M (2002) The oxford happiness questionnaire: a compact scale for the measurement of psychological well-being. Personality Individ Differ 33(7):1073–1082

Loewenstein G, Bryce C, Hagmann D, Rajpal S (2015) Warning: you are about to be nudged. Behav Sci Policy 1(1):35–42

Nishimura K, Yagi T (2019) Happiness and self-determination—an empirical study in Japan. Rev Behav Econ 6(4):385–419. https://doi.org/10.1561/105.00000113

O'Donoghue T, Rabin M (1999) Doing it now or later. Am Econ Rev 89(1):103–124

Prochaska JO, DiClemente CC, Norcross JC (1992) In search of how people change: applications to addictive behaviors. Am Psychol 47(9):1102

Thaler RH, Sunstein CR (2008) Nudge: Improving decisions about health, wealth, and happiness. Yale University Press, New Haven, Connecticut

Vlaev I, King D, Dolan P, Darzi A (2016) The theory and practice of nudging: changing health behaviors. Public Admin Rev 76(4):550–561

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Chapter 14
Education Policy and Behavioral Change in Science Learning—An Empirical Analysis Based on Japanese Data

Kazuo Nishimura, Tadashi Yagi, and Dai Miyamoto

Abstract The study of science subjects in school education is important for the advancement of science and technology. However, it is true that many students avoid science and mathematics. The significance of examining strategies for raising interest in science subjects and elevating learning benefits is considerable. We asked researchers and engineers who are applying science skills in work about their experience of education in science subjects, and their study of science subjects from elementary school through university. We then examined how their experience and study related to later capabilities as researchers and engineers. Based on data obtained, we analyzed the influence of education policy on science study behavior, as a factor in raising interest in science subjects and willingness to study science. Our results confirmed the importance that "associating science learning with daily life" has in exerting a positive influence on science learning behavior and on raising specialized skills. This is additional to the generally accepted concept of stimulating interest in science through class content at an early stage, in the early years of elementary school education. Meanwhile, a decline in the ratio of students who like science, an increase in students' perceptions that they are weak in science, a decline in the sense of strength in science, and an ongoing distancing from science have been highlighted as consequences of the "Relaxed Education" policy.

Keywords Education policy · Science learning · Behavioral change · Like science · Dislike science · Specialized skills

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1 Introduction

Science education in Japan has undergone significant changes over the past 30 years. In the university admission exams for the 2008 school year, the total number of applicants for engineering departments was 245,000. This represented a 37% decline compared with the 1992 school year. During the 1970s, the ratio of students studying physics in senior high school was in the 80–90% range. After the 1982 revision of curriculum guidelines, the ratio dropped sharply to the 30% range. It is reported to have fallen below 20% in 2008. In line with the so-called "Relaxed Education" policy, class hours and curriculum content were reduced three times, first in 1978, and then in 1989 and 1998. Education in science subjects deteriorated as a result.

This decline in the level of education in science subjects is sapping Japan's technological strength (Nishimura et al. 2018). Examining trends since the 1990s of patent application numbers by the four countries with the highest totals, the number of applications by Japanese people peaked in 2005 at about 530,000. By 2014, the total had declined by more than 10% to about 470,000. This trend is not seen with other countries (see Fig. 1). Furthermore, until 2011, Japan had the world's highest total patent applications. Today, Japan has fallen to third place, behind China and the US. The gap between Japan and South Korea is also shrinking. From the perspective of total patent applications, Japan's R&D strength can be confirmed as being on a downward trend, both relatively and absolutely. Additionally, processing of data obtained from the Thomson Reuters Web of Science (WoS) abstract database showed that, until the early half of the 2000s, Japanese people were in the top level internationally for number of engineering-related publications. However, as with number

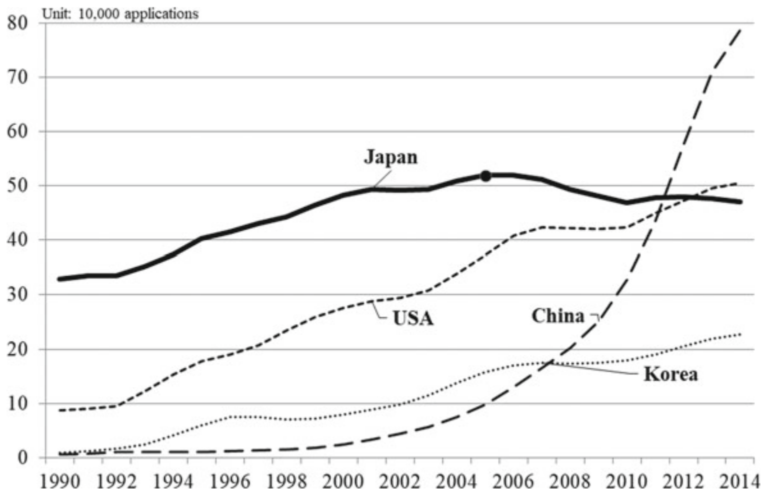

Fig. 1 Trends of total patent applications by applicants' countries of origin (three-year moving average) *Source* Indicator 1: Total patent applications (direct and PCT national phase entries) by applicants' origin, WIPO statistics database

of patent applications, the number of such publications by Japanese has continued to fall, relatively and absolutely, since about 2005. The decline of Japan's R&D strength therefore cannot be considered just a temporary phenomenon.

Globally, demand for and supply of R&D personnel have become strained in recent years. In particular, R&D personnel needed by industry for advanced technology are increasingly in short supply. Furthermore, obtaining talented R&D personnel from outside Japan is difficult. Evaluation of the effects that education policy has had on science learning behavior, and analysis of how education policy and teaching methods can modify science learning behavior, are vital steps in examining cultivation of talented R&D personnel for Japan in the future.

This chapter focuses on the results of questionnaire surveys we conducted in relation to science subject learning behavior, targetting Japanese engineers and people engaged in science-related research. Based on the data accumulated, we clarify characteristics of science study relevant to raising the capability of engineers and researchers. From there, we clarify what could modify willingness to study science. Additionally, analysis of the relationship of capability as researchers or engineers, with science education and study undertaken from elementary school through university, shows the effects that education policy changes have had on study behavior concerning science subjects.

Breakwell and Beardsell (1992) examined changes in study behavior concerning science and maths subjects, stemming from the influences of gender and social intimates including parents. Their study focused on children in the UK, between the ages of 11 and 14 years. Osborne et al. (2003) presented and analyzed the effects of the following seven issues as factors influencing willingness to study: (1) motivation to learn, (2) self-efficacy in science learning, (3) anxiety regarding science, (4) awareness of science, (5) science teacher perspectives on science study, (6) participation in extracurricular science activities, and (7) interest in a science-related occupation. Tytler (2014) surveyed existing research on how science education can be conducted to raise willingness to study, and learning benefits.

Eccles (1983) asserted that academic achievement of students is determined by a balance of two elements—the value of goals that students wish to achieve, and expectations toward potential for achievement. Additionally, Wan (2019) studied ten-year-old children in Hong Kong to determine effects of science learning motivation and self-efficacy on the willingness to learn science.

Referring to existing research as noted above, for this chapter we designed questionnaire surveys that would allow evaluation of factors stimulating behavior modification in science learning. The surveys targeted Japanese engineers and science researchers. Analyzing the data obtained, we examined factors that raise effectiveness of science education.

Section 2, below, explains the survey method and gives an overview of the data. Section 3 examines the education policy changes in Japan and analyzed the effects on formation of science capability. Section 4 clarifies factors drawing out interest in science considers. Section 5 examines the factors determining degree of strength in science in senior high school. Section 6 clarifies factors determining specialized skills of engineers and researchers.

2 Survey Method and Data Overview

The first batch of survey data was obtained in March 2016 through the research service (NTTCom Research) of NTTCom Online Marketing Solutions Corporation. The survey was titled “Questionnaire Survey on Perceptions in Engineering and Research Occupations” (1st Survey) and conducted via the internet. It focused on individuals who were working in engineering and research, and generally thought of as R&D personnel. Of the 153,272 questionnaires distributed, 17,440 preliminary survey responses were received. The number of full survey responses was 5241, giving a recovery ratio of 3.4%. After screening for engineering and research occupations, the final number of valid responses was 4,129. A follow-up survey was then implemented in March 2017, targetting respondents to the 1st Survey “Follow-up Questionnaire Survey on Perceptions in Engineering and Research Occupations” (2nd Survey). The survey content consisted of questions concerned mainly with likes and dislikes relating to sciences. The follow-through sample size for the 1st Survey and 2nd Survey was 2,065 respondents. An additional survey of respondents to the 2nd Survey was conducted in July 2017 “Questionnaire Survey on Study of Science in University” (3rd Survey). The follow-through sample size from the 1st Survey to the 3rd Survey was 1152 persons.

The data obtained had the following traits. Gender ratios were male 92.1% and female 7.9%, showing an overwhelming number of males. The academic record of university graduation or higher was 75.4%, and average age was 33.22 years (standard deviation 9.20 years). Of respondents who completed university undergraduate study or higher, 78.9% majored in science courses; 19.1% hailed from liberal arts courses; and 2.0% undertook integrated science/liberal arts courses. Average annual pre-tax income for all samples was 6,697,519 yen, with standard deviation of 3,600,000 yen.

3 Education Policy Changes and Effects on Formation of Science Capability

In Japan’s education policies, curriculum guidelines have been amended according to specific themes once almost every ten years, between 1961 and the present day. When the theme changed, so did the curriculum guidelines. As indicated in Table 1, the guidelines have therefore changed substantially, compared with education in the 1950s. Considering arithmetic and mathematics, for example, education from 1951 to 1960 was based on learning of discrete study units. This is called “Pre-relaxed Education I”. From 1961, focus shifted to perceptions of goals for arithmetic/mathematics, and the scholastic achievement that should be attained for those goals acquired importance. Arithmetic/mathematics education in the education period 1961–1970 focused on “Systematic Learning” during the “Pre-relaxed Education II” period. Over the period 1971–1979, the emphasis turned to “Education Modernization” during the “Pre-relaxed Education III” period, and curriculum guidelines were steadily revised

Table 1 Age group categories: curriculum guidelines during elementary school

	Respondent age groups at time of 1st Survey
Pre-relaxed Education I (1951–1960)	62 years or older
Pre-relaxed Education II (1961–1970)	52–61 years
Pre-relaxed Education III (1971–1979)	43–51 years
Relaxed Education I (1980–1991)	31–42 years
Relaxed Education II (From 1992–)	30 years or younger

to reflect the development of society. The era from 1980 to 1991 was given to "Relaxed Education". Content was gradually reduced in accordance with curriculum guidelines, to reduce study hours for children. Since 1992, curriculum guidelines have centered on cultivating ability to think, under the banner of "New Concepts of Academic Ability/Power of Life" during "Relaxed Education II".

We surveyed engineers and science-oriented researchers who received elementary school education in one of the curriculum guideline eras shown above. Respondents were also asked whether they liked or disliked science subjects during their time as university undergraduates. As the survey respondents were engineers and science researchers, it might be assumed there is a fundamental liking for science subjects. However, the survey results showed 72.3% selected "Liked", and 27.7% answered "Did not like". Of the respondents who declared they liked science subjects, 33.4% said they acquired a liking for science during the early years of elementary school. Meanwhile, 23.0% stated they acquired a liking for science during the later years of elementary school, 10.8% during junior high school, and only 5.1% during senior high school or later. In contrast, of the respondents who did not like science, 30.8% said their dislike emerged in junior high school, while 29.4% pointed to senior high school.

Figure 2 shows the ratios of respondents who stated they liked science subjects in university, according to curriculum guideline era and age group. Among engineers and researchers who were educated during the "Pre-relaxed Education III" era, 78% declared they enjoyed science subjects during university. In contrast, the ratios of liking for science subjects fell to 73% for respondents from the "Relaxed Education I" age group, and to 64% for the "Relaxed Education II" age group.

To obtain detailed analysis of the characteristics of science learning, questions in the surveys used for this chapter covered 56 items relating to science study from elementary school through senior high school. The Appendix shows the outcome of a search-type factor analysis of the survey results. The methods used for factor extraction were principal component analysis, and rotation by the Equamax method with Kaiser normalization. The variables extracted through factor analysis were: (1) enthusiasm toward studying science from junior high school onward, (2) a sense

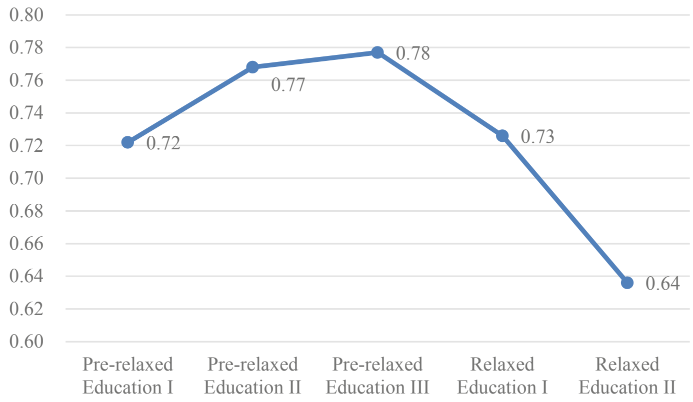

Fig. 2 Ratios of liking for science subjects as undergraduates, according to curriculum guideline era

of strength in science from junior high onward, (3) a sense of strength in science during elementary school, (4) studying science with friends, (5) association of science learning with daily life, (6) affinity for the content of science studies, (7) enthusiasm toward science learning during elementary school, (8) patience in learning science during elementary school, and (9) a sense of weakness in science from elementary school through university. The correlation coefficient between these samples was confirmed as 0 by orthogonalization.

Of the nine variables extracted from results of factor analysis, we examine two variables according to curriculum guideline era and age group: (2) a sense of strength in science from junior high onward, and (9) a sense of weakness in science from elementary school through university. Figure 3 plots the sense of strength and sense of weakness in science in terms of curriculum guidelines by era and age group. As shown, since the introduction of "Relaxed Education", the sense of weakness in science has climbed sharply, whereas the sense of strength in science capability has seen a major decline. These results can be interpreted as showing that the "Relaxed Education" policy caused a major decline in science capability.

4 Education Periods in Which "Like Science" and "Dislike Science" Emerged, and the Causes

The previous section showed how education policy changes led to changes in the ratios of "like science" and, correspondingly, in the sense of strength or weakness in science. In this section, we analyze for triggers leading to a liking for science, and the education periods in which they occurred. To narrow down the triggers for acquiring a liking for science, the surveys offered the following choices: "Class experiments", "Class talk was interesting", "Understood class talk", "Books",

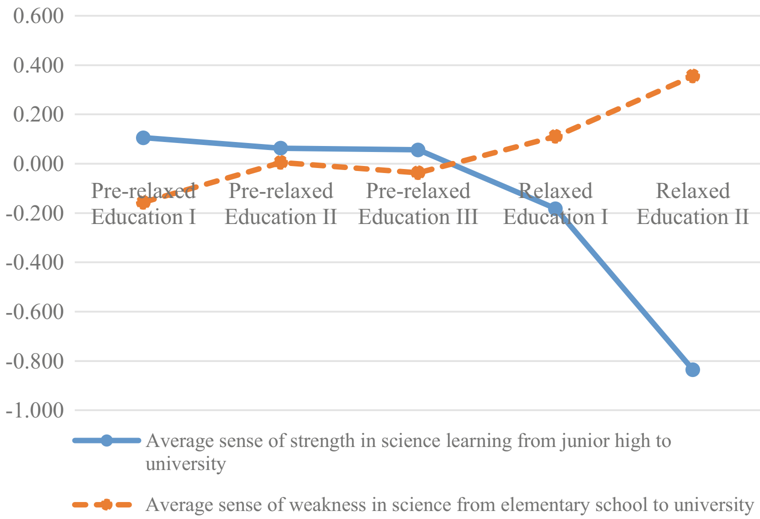

Fig. 3 Science capability by curriculum guideline era/age group

"Extracurricular experiments, in clubs, etc.", "Events such as talks by scientists and researchers", "Astronomical observations", "Television programs", "Family influences, incl. parents' occupations" and "Other".

Figure 4 shows the education periods in which respondents acquired a liking for science and the triggers in each period. In elementary school, the most common trigger for attaining a liking for science was "Class experiments". This trigger had a high ratio in all education periods.

The second and third most important triggers for acquiring a liking for science were "Class talk was interesting" and "Understood class talk". In particular, we need to note the rising ratio of "Understood class talk", moving from junior high school to senior high school. The influence of "Books" was also large, and the figure shows classroom instruction and books are triggers for acquiring a liking for science.

The surveys also asked about why respondents came to dislike science. The choices offered were: "Classes were difficult and I could not understand", "Classes were uninteresting", "Disliked insects and other creatures", "Experiments were uninteresting", and "Experiments were difficult and I could not understand". Figure 5 shows the education periods in which respondents turned away from science, and the triggers. The most common trigger in each education period was "Classes were difficult and I could not understand", followed by "Classes were uninteresting". This underlines the importance of the nature of classroom instruction.

From Figs. 4 and 5, we understand classroom instruction in schools has a considerable influence on whether students acquire or lose interest in learning science.

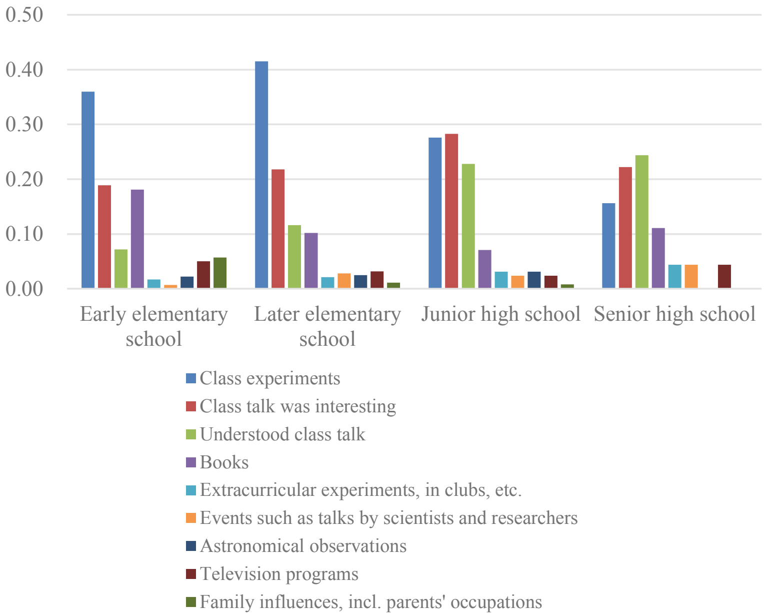

Fig. 4 Education period and reasons for acquiring a liking for science

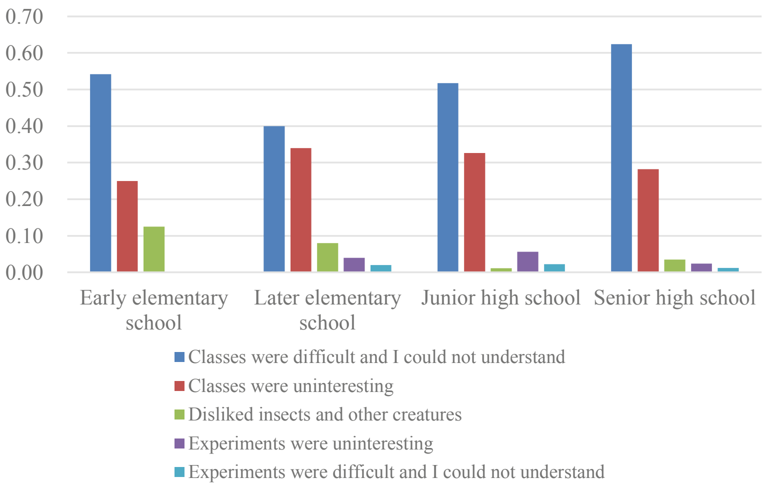

Fig. 5 Education period and reasons for turning away from science

5 Factors that Determine the Degree of Strength in Physics in Senior High School

Additionally, we conducted multivariate regression analysis of factors determining degree of strength in physics in senior high school. These included responses to the question “Did you have any experience during classroom instruction or experiments in science that inspired awe or wonder (Inspiring class experience)?”, and reasons for acquiring a liking for science or turning away from science as discussed in Sect. 4, in addition to factors extracted through factor analysis.

Figure 6 is based on results of multivariate regression analysis. Bar heights represent standardized coefficient values of elements with statistically significant influence on degree of strength at the 5% significance level. Comparison of standardized coefficient values allows comparison of the strength of influence of each factor. When the value of a factor is negative, it has a negative effect on degree of strength.

The following variables have a strong, positive influence on degree of strength in physics in senior high school: “Began to like science in early elementary school (Early elementary school dummy variable)”, “Understood class instruction”, “Inspiring experience in science”, “Associated science learning with daily life”, “Class talk was interesting” and “Had affinity for science study”.

“Class experiments” should be noted among factors that did not influence degree of strength. Theoretical understanding of the content of experiments is thought to be important for linking “Class experiments” to formation of science capability. Learning to like science in the early years of elementary school has a positive influence on degree of strength.

It is likely that having interest in science and undertaking appropriate study in the early years of elementary school will raise level of understanding of science in class

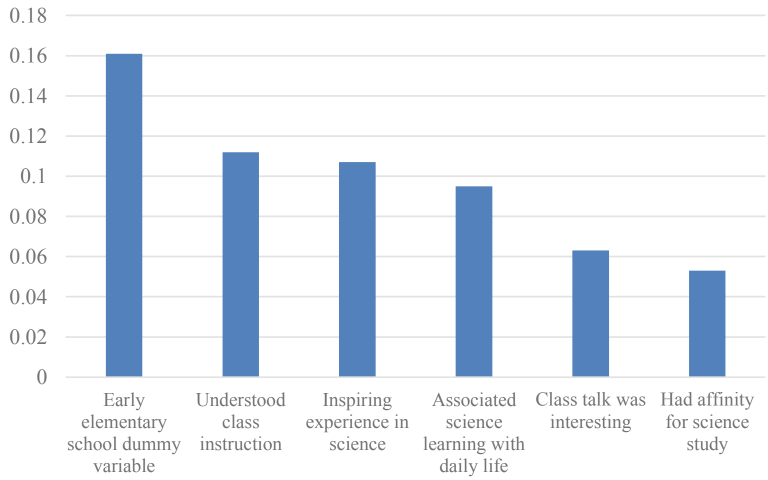

Fig. 6 Factors that determine degree of strength in physics in senior high school

instruction, and subsequently the longer-term potential for formation of capability as an engineer or science researcher. Furthermore, associating science learning with daily life should result in more than simply a higher degree of strength in physics. Crucially, comprehension of compound relationships of individual scientific truths in real life is also shown as having a strong influence on formation of capability as an engineer/researcher.

6 Factors that Determine Specialized Skills of Engineers and Researchers

In this section, we analyze science learning characteristics that influence ability to accomplish activities as engineers and researchers. One survey question asked, "Do you feel you have occupational skill that would give you recognition outside the company as a specialist in your field of endeavor?" Response choices were on six levels: (1) no, (2) not much, (3) closer to no than yes, (4) closer to yes than no, (5) a little, and (6) yes. The responses to this question are interpreted as "Confidence in specialized skills".

Additionally, we examined the number of patent applications, a number that might be considered representative of specialized skills. However, many survey respondents were in occupation types or positions unrelated to patent applications, and the ratio of respondents who stated they had lodged at least one patent application was not high, at just 28.2%. Therefore, we did not use number of patent applications as a variable representing specialized skills. Even so, regarding respondents who stated they had lodged at least one patent application, regression of number of patent applications on confidence in specialized skills showed statistical significance at significance level of up to 1%, and consistency of confidence in specialized skills and number of patent applications. Ultimately, we used "Confidence in specialized skills" as a proxy variable for measuring specialized skills. This is referred to as "specialized skills", below.

Using these factors and degree of strength in physics and chemistry in senior high school, we analyzed the effect of science learning experiences on specialized skills. In Fig. 7, from characteristics of science learning in elementary, junior high, and senior high school we extracted only elements having statistically significant influence on specialized skills at the 5% significance level. Comparison of standardized coefficient values allowed a comparison of strength of influence of individual factors.

As shown by Fig. 7, of factors explaining current specialized skills, (1) degree of strength in physics in senior high school, (2) enthusiasm toward learning science from junior high school onward, and (3) association of science learning with daily life were statistically significant at the 5% significance level and imparted a positive influence. Degree of strength in chemistry was not statistically significant as a factor for explaining current specialized skills. Whereas degree of strength in physics in senior high school had a strong influence on specialized skills, degree of strength in

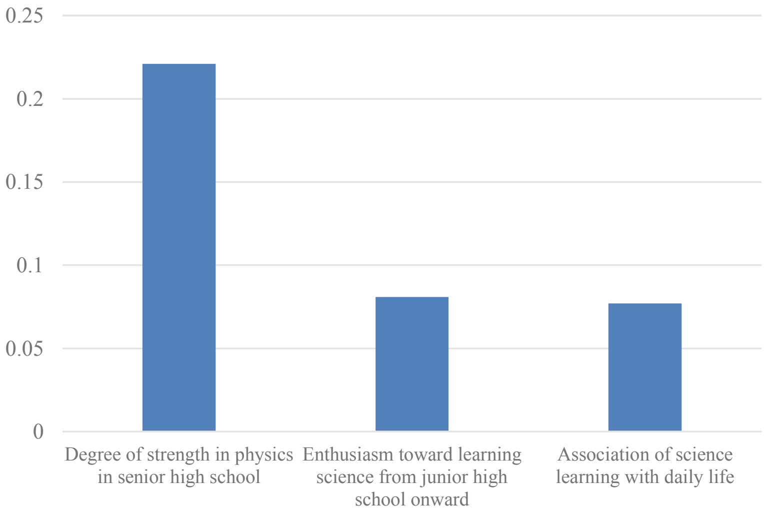

Fig. 7 Characteristics of science study in elementary/junior high/senior high schools, and specialized skills

chemistry in senior high school had no influence. This suggests, in contrast to study of chemistry, the study of physics contributes strongly to formation of fundamental capability.

The analyses above clarified factors behind science capability in elementary/junior high/senior high schools, and formation of specialized skills as engineers and scientists. An important point common throughout is that modification of science learning behavior is triggered by raising interest in science as part of daily life, beginning with the early years of elementary school education. This then links to formation of capability in science and formation of specialized skills as engineers and scientists. Revision of the state of science education from the early years of elementary school onward, and provision of an environment that can continue to stimulate interest in science, can be considered vital for cultivating a liking for science in children.

7 Conclusion

In this chapter, we analyzed connections between learning behavior in schools and formation of specialized skills, and factors influencing modification of such learning behavior, based on surveys of researchers and engineers. We then analyzed changes emerging in science capabilities of engineers and researchers, resulting from revisions applied to education policy. The findings obtained are as follows.

First, we showed that the "Relaxed Education" policy caused a major decline in science capability. Shortened class instruction hours in science subjects due to the policy led to a decline in children's interest in science, and a decline in the ratio of children who are strong in science. These results emphasize the importance of education policy on science ability formation.

Next, factors raising the important degree of strength in physics are: "Learning to like science at an early stage, in the early years of elementary school", "Class instruction is understood/interesting", "Inspiring experiences in science", "Associating science learning with daily life", and "Acquiring an affinity for learning science". Furthermore, in addition to raising degree of strength in physics, associating science learning with daily life enhances skills as engineers and researchers. It is interesting to note that the degree of strength in physics in senior high school has a strong influence on specialized skills of R&D personnel. In contrast, the degree of strength in chemistry does not have any effect.

The results of this research suggest the importance of stimulating interest in science at an early stage and of associating science learning with daily life, to raise science capability. Further research is needed to determine methods that would be effective for stimulating interest in science at an early stage of school education.

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Appendix

Results of factor analysis of responses to surveys on perceptions relating to science (correlation coefficients between questionnaires and factors).

	Enthusiasm toward study of science from junior high	Sense of strength in science from junior high	Sense of strength in science in elementary school	Studied science with friends	Associated science learning with daily life	Affinity for content of science learning	Enthusiasm toward study of science in elementary school	Patience in learning science in elementary school	Sense of weakness in science
18. (Junior high to university graduation) Recalled and reviewed important matters repeatedly when studying for tests	*0.732*	0.185	0.002	0.157	0.079	0.092	0.157	0.279	-0.047
19. (Junior high to university graduation) Summarized key points of various materials learned, to further understanding	*0.731*	0.139	0.02	0.198	0.103	0.105	0.313	0.137	-0.065
15. (Junior high to university graduation) Reorganized notes when studying, for better recall of material learned	*0.694*	0.057	0.033	0.218	0.019	0.071	0.404	0.093	0.011
16. (Junior high to university graduation) Worked individually on exercises not included in homework	*0.668*	0.199	0.097	0.143	0.17	0.019	0.22	-0.005	-0.13
17. (Junior high to university graduation) Completed study tasks even if the material being studied was boring and uninteresting	*0.627*	0.213	0.034	0.109	0.063	0.07	0.125	0.307	-0.067
20. (Junior high to university graduation) Applied material learned earlier when studying new topics	*0.603*	0.296	0.09	0.092	0.277	0.135	0.128	0.212	-0.217
13. (Junior high to university graduation) When studying, I would put important but difficult words into my own words	*0.593*	0.191	0.049	0.177	0.134	0.011	0.223	0.286	0.002
14. (Junior high to university graduation) Always tried to make sense of what the teacher was saying, even if I did not understand at the time	*0.584*	0.152	0.017	0.114	0.142	0.09	0.009	0.459	-0.012

12. (Junior high to university graduation) When doing homework, I tried to recall what was taught in class, to thoroughly answer problems	*0.574*	0.156	0.071	0.119	0.085	0.088	0.028	0.558	-0.053
11. (Junior high to university graduation) Compiled hints from class instruction, books, etc., when studying for tests	*0.513*	0.146	0.118	0.044	0.116	0.135	-0.089	0.501	-0.13
8. (Junior high to university graduation) I believe I achieved good academic results in science study	0.167	*0.806*	0.307	0.072	0.119	0.205	0.026	0.008	-0.234
7. (Junior high to university graduation) I believed I was strong in science studies	0.145	*0.804*	0.351	0.063	0.139	0.206	0.038	0.018	-0.213
6. (Junior high to university graduation) I had confidence in ability to learn science	0.162	*0.799*	0.363	0.057	0.163	0.204	0.022	0.016	-0.215
5. (Junior high to university graduation) I believe I studied science thoroughly	0.186	*0.766*	0.395	0.049	0.138	0.214	0.021	0.032	-0.183
2. (Elementary school) I had confidence in ability to learn science	0.019	0.243	*0.836*	0.032	0.147	0.249	0.109	0.139	-0.19
1. (Elementary school) I believe I studied science thoroughly	0.034	0.224	*0.832*	0.034	0.133	0.239	0.113	0.162	-0.162
4. (Elementary school) I believe I achieved good academic results in science study	0.025	0.272	*0.813*	0.028	0.127	0.264	0.08	0.116	-0.21
3. (Elementary school) I believed I was strong in science studies	-0.015	0.277	*0.808*	0.035	0.138	0.257	0.098	0.109	-0.216
15. (Junior high to university graduation) I studied science together with friends	0.199	0.079	0.027	*0.85*	0.133	0.008	0.035	0.113	0.005
14. (Junior high to university graduation) My friends and I helped each other with science-related matters and set problems for each other	0.247	0.103	0.006	*0.807*	0.189	0.025	0.058	0.084	-0.071
16. (Junior high to university graduation) I talked with other people about my difficulties in science studies	0.164	0.054	0.03	*0.782*	0.087	-0.105	0.098	0.085	0.173
7. (Elementary school) I studied science together with friends	-0.04	-0.045	0.051	*0.694*	0.249	0.005	0.354	0.188	0.048

8. (Elementary school) I talked with other people about my difficulties in science studies	-0.076	0.022	-0.004	*0.658*	0.155	-0.108	0.388	0.087	0.256
6. (Elementary school) My friends and I helped each other with science-related matters and set problems for each other	-0.018	-0.031	0.115	*0.61*	0.357	0.036	0.384	0.179	0.015
13. (Junior high to university graduation) Added relevant pictures and illustrations to my notes as I studied science	0.371	0.075	-0.053	*0.49*	0.392	0.061	0.165	0.013	-0.052
5. (Elementary school) Added relevant pictures and illustrations to my notes as I studied science	0.057	-0.077	0.036	*0.442*	0.396	0.074	0.473	0.074	0.019
4. (Elementary school) Associated science studies with my day-to-day life	-0.067	0.005	0.167	0.191	*0.771*	0.105	0.26	0.184	-0.059
3. (Elementary school) Associated science studies with my interests and things I know well	-0.062	0.037	0.206	0.079	*0.77*	0.133	0.242	0.161	-0.085
11. (Junior high to university graduation) Associated science studies with my interests and things I know well	0.271	0.264	0.094	0.235	*0.71*	0.11	-0.065	0.101	-0.19
2. (Elementary school) Thought science study would be beneficial to my future	-0.051	0.07	0.191	0.137	*0.684*	0.064	0.326	0.093	0.007
12. (Junior high to university graduation) Associated science studies with my day-to-day life	0.263	0.25	0.026	0.345	*0.679*	0.08	-0.05	0.084	-0.121
10. (Junior high to university graduation) Thought science study would be beneficial to my future	0.288	0.305	0.14	0.19	*0.658*	0.098	-0.062	0.029	-0.137
9. (Junior high to university graduation) I had thought about what I would need if I were to be accepted by a higher school of my choice	0.364	0.149	0.104	0.247	*0.447*	0.072	0.001	-0.013	0.045
4. (Elementary school) I felt comfortable studying science	0.017	0.043	0.381	-0.019	0.078	*0.832*	0.001	0.082	-0.173
3. (Elementary school) I studied science without concern	0.02	0.042	0.382	-0.059	0.075	*0.83*	-0.009	0.098	-0.158
2. (Elementary school) I was able to study science with peace of	0.023	0.061	0.424	-0.003	0.095	*0.786*	0.014	0.077	-0.163

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7. (Junior high to university graduation) I studied science without concern	0.102	0.517	0.019	-0.021	0.074	*0.731*	-0.009	0.052	-0.211
6. (Junior high to university graduation) I was able to study science with peace of mind	0.12	0.545	0.044	0.005	0.081	*0.705*	0.029	0.02	-0.219
8. (Junior high to university graduation) I felt comfortable studying science	0.08	0.575	0.012	0.003	0.054	*0.698*	0.039	0.017	-0.228
9. (Elementary school) Summarized key points of various matters learned, to further understanding	0.246	0.008	0.053	0.179	0.102	0.03	*0.739*	0.337	-0.043
5. (Elementary school) Reorganized notes when studying, for better recall of material learned	0.205	-0.001	0.035	0.184	0.01	-0.001	*0.712*	0.317	0.017
6. (Elementary school) Worked individually on exercises not included in homework	0.194	0.081	0.195	0.152	0.14	-0.037	*0.681*	0.185	-0.04
8. (Elementary school) Recalled and reviewed important matters repeatedly when studying for tests	0.265	-0.012	0.05	0.188	0.069	0.021	*0.64*	0.462	-0.009
10. (Elementary school) Applied material learned earlier when studying new topics	0.149	0.069	0.182	0.086	0.241	0.13	*0.51*	0.442	-0.157
1. (Elementary school) I had thought about what I would need if I were to be accepted by a higher school of my choice	-0.06	0.06	0.091	0.225	0.312	-0.019	*0.471*	-0.035	0.271
2. (Elementary school) When doing homework, I tried to recall what was taught in class, to fully answer problems	0.108	0.018	0.124	0.141	0.074	0.087	0.259	*0.764*	-0.028
4. (Elementary school) Always tried to make sense of what the teacher was saying, even if I did not understand at the time	0.136	-0.011	0.128	0.078	0.101	0.064	0.193	*0.744*	-0.02
1. (Elementary school) Compiled hints from class instruction, books, etc., when studying for tests	0.026	-0.01	0.123	0.08	0.083	0.109	0.212	*0.707*	-0.013
7. (Elementary school) Completed tasks even if the material being studied was boring and uninteresting	0.218	-0.031	0.173	0.078	0.04	0.042	0.347	*0.519*	-0.054

3. (Elementary school) When studying, I would put important but difficult words into my own words	0.053	0.073	0.096	0.166	0.132	-0.004	0.459	*0.51*	0.003
3. (Junior high to university graduation) When studying science, I quickly lost interest	-0.141	-0.381	-0.075	0.026	-0.095	-0.125	-0.007	0.028	*0.792*
4. (Junior high to university graduation) When doing difficult science problems, I often tired quickly and gave up	-0.119	-0.394	-0.049	0.039	-0.075	-0.118	-0.031	0.037	*0.781*
2. (Elementary school) When doing difficult science problems, I often tired quickly and gave up	0	0.008	-0.416	0.033	-0.034	-0.18	-0.055	-0.038	*0.772*
1. (Elementary school) When studying science, I quickly lost interest	-0.003	0.02	-0.423	0.037	-0.05	-0.185	-0.041	-0.056	*0.767*
1. (Elementary school) When studying science, I tended to become anxious	0.061	-0.041	-0.36	0.117	-0.037	-0.31	0.12	-0.083	*0.528*
5. (Junior high to university graduation) When studying science, I tended to become anxious	0.104	-0.368	0.094	0.085	-0.027	-0.252	0.074	-0.047	*0.509*

References

Breakwell GM, Beardsell S (1992) Gender, parental and peer influences upon science attitudes and activities. Public Underst Sci 1(2):183–197

Eccles JS (1983) Expectancies, values, and academic behaviors, advances in motivation and achievement. In: Spence JT (ed) Achievement and achievement motives: psychological and sociological approaches, San Francisco, CA, W.H. Freeman and Company, pp 75–146

Nishimura K, Miyamoto D, Yagi T (2018) History of changes to the curriculum guidelines and the decline in research and development productivity in Japan. J Qual Educ 9:1–22

Osborne J, Simon S, Collins S (2003) Attitudes towards science: a review of the literature and its implications. Int J Sci Educ 25(9):1049–1079

Tytler R (2014) Attitudes, identity, and aspirations toward science. In: Lederman NG, Abell SK (eds) Handbook of research on science education. Routledge, Abingdon, pp 82–103

Wan ZH (2019) Exploring the effects of intrinsic motive, utilitarian motive, and self-efficacy on students' science learning in the classroom using the expectancy-value theory. Res Sci Educ. Available via DIALOG. https://doi.org/10.1007/s11165-018-9811-y. Accessed 15 Jan 2020

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Chapter 15
The COVID-19 Outbreak and Public Health Issues: An Interdisciplinary Approach

Anavaj Sakuntabhai and Bernard Thomann

Abstract This chapter aims to present the content of the discussions that took place following he presentations of the workshop "The COVID-19 Outbreak and Public Health Issues: an Interdisciplinary Approach". Discussion focused in particular on how interdisciplinary research can be useful for policy, on how the pandemic changed the way to do research. It was in particular question of research purpose testing, epidemiological surveys, and its related matters such as reliability, technology, methods, samples, ethics. Were also discussed the question of respective weight of social and biological factors in the diffusion of the epidemy and how collective representations could affect information and population trust in public health policies.

Keywords Covid19 · Interdisciplinary research · Epidemiology · Life sciences · Social sciences · Policy

1 Introduction

On December 16 and 17, 2020 the workshop "The COVID-19 Outbreak and Public Health Issues: an Interdisciplinary Approach" took place hosted by Anavaj Sakuntabhai and Bernard Thomann of Institut français de recherche sur le Japon à la Maison franco-japonaise. There were eight presentations during the two days (presenters: Yano, Paul, Sala, Buhnik, Hirota, Ladmiral, Giles-Vernick, and Matsuda), presided over by Thomann and Anavaj. Seven chapters of this book are based on those presentations.[1] The presentations were followed by a long sequence of discussions, in which many of the coauthors of the presentations participated. This chapter aims to present

[1] The program can be found at https://www.mfj.gr.jp/agenda/2020/12/16/rieti/ and https://www.mfj.gr.jp/agenda/2020/12/16/rieti/.

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the content of these discussions, which set the tone of our joint research. The editors of the book express many thanks to the Institut français de recherche sur le Japon à la Maison franco-japonaise for the wonderful workshop.

2 Covid and the New Need for Interdisciplinary Research. How Interdisciplinary Research Can Be Useful for Policy?

One of the purposes of our workshop was to build links between different researchers from biological, medical, and social sciences. It is not an easy task because of very different scientific traditions and practices. Bernard Thomann pointed out that we use very different kind of data sources. For example, some researchers used aggregated data, some used individual data. Most data used are qualitative from interviews; when quantifiable, different methods are used. Therefore, it is not easy for researchers to exchange their data (especially data containing personal information), and methods, although we learn a lot when we present our results. Bernard Thomann had questions on how the COVID-19 pandemic had changed the life of researchers. Of course, COVID-19 changed their everyday life. But it also changed the way scientists see their research fields. One year ago, nobody was researching COVID-19 but in this panel, everybody is now working on it. He asked two questions to Shigeru Hirota. His first question was how the COVID-19 pandemic changed the way we practise our field or our discipline? Also, how we realized that we needed more than before an interdisciplinary approach? The second question is about expected results from our researches. Certainly, there are results that we expect and results that we do not expect. Some results could be counter-intuitive. Shigeru Hirota replied that indeed the COVID-19 outbreak had changed our practices and styles of our research. Makoto Yano prepared an interdisciplinary research program more than 4–5 years ago. Now we have to work harder to struggle with this situation, but he was not sure what kind of results we will obtain. He does not know if it will be counterintuitive or not but we have to work harder. Fumihiko Matsuda added that, as compared to France, there is are a much smaller number of patients or people who get infected. Of course, ideally, if they have sufficient number of people who get infected, who had past infection history in the planned study, then they can compare different factors like the social capitals, biological characteristics, and so on. In Nagahama city where they performed longitudinal cohorts, they do not expect to have a large number of people who get infected. But still, they can try to associate social capitals and the change of activities during this COVID-19 pandemic period. They can ask questions about whether individuals have spent more time staying at home or whether their activities have not changed. They can correlate the chance of getting infected with gambling, income, or trust in others. We may have some correlations, which can be used for future policy planning. In this sense, it is crucial to have the social life science study in Nagahama cohort by using the COVID antibody test. This is a very good example of a multidisciplinary study studying human beings to take into account the mental activity of people.

Makoto Yano gave his opinion that this particular occasion symbolizes what we will see in the future about our research. Because of COVID-19, we have now really a common interest no matter which field we are in. There are targets that all scientists want to understand: why COVID-19 is spreading badly and strangely in a defined culture, in defined places, and in a defined way. All of us would like to understand the risks from very different viewpoints. He said that this occasion was really wonderful, and that he was very grateful to everybody who gave a presentation in such a way that people who are outside of the field can understand what others are thinking about their interests and their motivations for their own research. Because this kind of occasion was made possible through online conference, we are going to have a totally different type of atmosphere in the international research field, collaborating between different fields.

3 How Covid-19 Changed the Way to Do Research?

Olivier Telle from CNRS India raised a question about how COVID-19 had really changed the way we work. As a health geographer, it was very difficult to get access to public health data. During his Ph.D., he spent 1–2 years to convince municipalities and government of India to give him dengue data. Recently, we can get access to all the COVID-19 data online. They have already been geo-referenced, which means that they are already specialized. We therefore have work that has already been done. It is then possible to compare, for example, the diffusion of COVID-19 influence in Japan with other countries.

In the past, it was very difficult for social scientists to access data without collaboration with biologists. Thanks to the COVID-19 pandemic, these datasets are more accessible nowadays. We can test our hypotheses, for example, about social disparities and the links with COVID-19. This is very important for social scientists. It will be a big change to bring social and biological sciences together—although it is not easy and it needs time to explain biology to social scientists and vice versa.

Sophie Buhnik wondered whether researchers at the Institut Pasteur had already studied the possible long-term effects of COVID-19 lockdown measures on cognitive and physical health, especially of the elderly. Recently, there was an article concerning elderly people in Japan who were active. Many policies in ageing societies all promoted elderly to maintain physical health for greater life expectancy. Lockdown measures have significantly diminished the time spent in walking or moving and, therefore, have potential negative effects. Needless to say that there is a lack of communication, which has a detrimental effect especially for people who are in retirement homes, who cannot see their relatives. It has enormous effect on not only their morale but also their cognitive health. They cannot speak and touch their relatives who could visit them in their retirement homes. Are some groups inside the Pasteur Institute already interested in this issue?

4 The Question of Research Purpose Testing, Epidemiological Surveys, and Its Related Matters: Reliability, Technology, Methods, Samples, Ethics

A group made up of Fumihiko Matsuda, Shigeru Hirota, and Makoto Yano studied social factors influencing the spreading of COVID-19 in Nagahama city, which is a medium-sized city. The medical school of Kyoto University, led by Professor Matsuda established a longitudinal cohort for genomic study in the city in 2007. They did the very first baseline study between 2007 and 2010. They have collected chronological and biological data. They have designed a cohort so that many different studies can be added. Fumihiko Hirota and Makoto Yano started this study in 2014. They conducted a questionnaire on social and economic behaviours. They added data on the economic side of the population on top of basic information obtained from a long-time survey. The reason for choosing Nagahama is that it is not very far from Kyoto and people are very supportive to this large-scale cohort.

Sophie Buhnik had a question related to the questionnaire distribution and the respondents. Do you have administrative and local support? How is the questionnaire welcomed by local government? Do you conduct them in cooperation with other organizations? Fumihiko Matsuda replied that researchers from the universities are not allowed to have personal information of the participants. Whenever they conduct a paper-based questionnaire survey, they ask the city of Nagahama and also a non-profit organization (NPO) that supports the study to make the necessary arrangements to send and to receive the questionnaires so that university staff do not touch/see the envelope with the name and the address of the participants. In short, it is the city and NPO that take care of this administrative procedure, and the research team take care of the research design and analysis.

There is another question related to the cohort. Researchers are not able to survey all the households of the area. So, was there any sampling method to select a quite diverse panel in terms of social background and other characteristics? The study is based on voluntary answers, so what kind of bias can it bring to this cohort of respondents? Shigeru Hirota explained that although the characteristics of the participants have several kinds of bias on gender composition or education, they utilized the benefit of the voluntary basis. If possible, they have to adjust the bias but, first of all, they gather information from the population. The reason why we limit the age group to those under 65 is because the probability of the infection is much higher than the younger and the older age group. Makoto Yano admitted that they expected a very strong bias for a social scientific viewpoint. But at the same time, the beauty of this research is that it is tacked on to the medical and genomic data. It is very unique to associate social behaviours to a cohort with biological and medical data. Fumihiko Matsuda had the cohort data capturing the medical aspects of people, their respondents, over a more than ten-year span. The association study based on this longitudinal medical cohort data is a very interesting thing to do as a social scientist. As a result, from the viewpoint of social science, there is bias. Even if there is bias, they get lots of knowledge out of the study in terms of the relationship between life science and social science.

The metropolitan government of Tokyo launched a campaign to assess seroprevalence. They are now recruiting 3000 people to know what the technology will be used for and what type of antibodies will be tested. In the past survey of a serological study, they used the antibody test kit manufactured by Abbott or Roche. Both of them target two antigens of virus. They found seropositive individuals, two people who are seropositive in both tests and the other five or six are seropositive for one test and not for the others. The accuracy of the result is not that satisfactory. The antibody test technology developed by Institut Pasteur is much more sensitive and specific.

What is the sample size? It would be interesting to have serology data of large population where there was a low transmission level like in Japan. This study will help us to assess better the level of asymptomatic infection and to understand better who transmits the virus. Fumihiko Matsuda explained that they will start the study in January with a target sample size of 3000 in Nagahama city. In this community-based cohort, they will test once. In Kyoto University Hospital, they will follow up with around 1000 healthcare workers. They will follow them up three or four times—the first survey in January, the second in March, the third in June, and the fourth next autumn. They continuously check the health status of healthcare workers. They do not have to set up a new sample collection, but they can use the samples that are collected for some other purpose.

They will do the antibody test and social science study in parallel. They will start with the sociological survey. The measurement of antibody will take place later. Once they get the samples, they can measure the samples at any time, as we can keep the materials in good condition.

Lastly, there is a question on the ethics of using people movement data from the Facebook application. Samuel Benkimoun explained that Facebook is aware of this concern. They provided the data in an aggregated form. There is no individual data and no data of underage individuals (less than 18 years old). And even more important, the data is only collected from people who agreed to share their location with the Facebook application. For example, they provided data in the form of a grid. They did not provide data if there are fewer than ten people inside a grid. The reason is that this data is too precise and cannot guarantee the privacy of the users.

5 The Question of Respective Weight of Social and Biological Factors in the Diffusion of the Epidemy

As was emphasized above, the contribution of the human and social sciences to the understanding of the epidemic was one of the main themes of the discussion. Makoto Yano's work on the US shows that people's attitudes towards risk can vary considerably from one country to another, and that, whatever the location, getting people to accept social distancing or wearing masks is a particularly difficult challenge for the authorities. All the more so as these very behaviours can be a political positioning issue and blur the message of scientific experts. Indeed, President Trump has encouraged behaviours of defiance of protective measures advocated by scientists, by highlighting the value of courage. It has been pointed out that Florida, led by a Republican close to Donald Trump, has particularly suffered from Covid 19. According toMakoto Yano, if the message of the president and the governor is convergent, it has a positive effect on people's behaviour.

The learning effect of prophylactic methods by the populations confronted with the pandemic is thus blurred by a large number of factors that make the contribution of social sciences particularly valuable. Thus, one example raised by the discussion beyond the influence of political messages is the influence of city size. As Samuel Benkimun highlights, an important point is how these different factors interact with each other—for example, the learning capacity of populations with the size of the city. In response to this question, Makoto Yano says that this relationship is complex to interpret. At first sight, the larger the city, the stronger the epidemic. Thus, COVID-19 was seen as primarily a disease of large cities, especially those in New York and New Jersey. But, on the other hand, what the data shows is that if you look at a particular region, the larger the city, the lower the number of cases per capita. This may seem surprising, but it confirms his initial conjecture that people have come to learn, struck by what was happening in New York, that the more urban the environment, the more careful you have to be. However, this becomes even more complicated when we realize that in the really densely populated areas, this effect disappears. It then appears that the factor of a large, densely populated city becomes more powerful than the factor of the population learning to take protective measures.

Bernard Thomann asked if the learning factor itself should be relativized since over time it does not have as much influence—many people get tired of the mask and social distancing, as is the case today in France. However, Makoto Yano believes that it should be interpreted for a given moment, the beginning of the epidemic, since the data used was collected on April 15, 2020. At that time, there was still a much purer effect between learning and size of the city than today where there are more and more factors to take into account. He feels that another study should be conducted today.

Another social factor to consider is the healthcare system. In response to a question from Richard Paul, Remi Scoccimaro mentioned the fact that hospitalization can cost a lot of money in Japan and that this can influence people's behaviour. In relation to this question of the economic capital factor, Bernard Thomann asked Remi Scoccimaro if his thesis that the richest neighbourhoods are also those most affected by the epidemic should not also take into account the age factor. Indeed, some of the richest neighbourhoods, especially the neighbourhoods with large luxury mansions, are also inhabited by relatively young people who protect themselves less, while in less affluent neighbourhoods, on the outskirts, there is an older population. Rémi Scoccimaro's answer is that this phenomenon may be true, but not everywhere. In the residential part of western Tokyo, there are clusters of neighbourhoods that are both rich and old.

Guillaume Ladmiral asked a methodological question about the way in which the wealth of a district is determined and thus on what condition it is really possible to make a link between the level of contamination and the level of wealth. For Rémi Scoccimaro, it is the price of land. Here again, as for other indicators, one must be careful because, in Tokyo, people without economic means can live in the middle of rich districts, such as Shibuya. However, with the destruction of the oldest houses, which were often inhabited by elderly people, this phenomenon is more and more marginal. Thus, according to him, the price of land is a good indicator, which can be more easily cross-checked with the indicators of the level of contamination.

Finally, another characteristic of these rich districts, which may explain why they are more contaminated, is that they are inhabited by rich foreigners who travel a lot. The Japanese living in these areas are themselves more mobile than the rest of the population. Indeed, as Guillaume Ladmiral points out, the National Institute of Infectious Diseases has shown that the strain coming from Wuhan in China disappeared quite early, at the end of March. So the strains that caused the next waves of infection came from the US and Europe. And they were mainly introduced by Japanese people coming back from vacation in March and April or professionals coming back from their missions abroad. For example, if you look at Aomori Prefecture which had very few cases, the virus was introduced there by a group of retirees returning from Spain and Kanto, and by students returning from the US. The complexity resulting from the interaction between the different factors is underlined by Olivier Telle, for whom a simple factor—the elderly are less affected for example—can hide a more complex phenomenon, notably that the elderly live more in rural areas. However, Guillaume Ladmiral, who in his study tries to take into account a very large number of factors in his analysis of social determinants, points out that this complexity is not always possible to deal with satisfactorily since data are not always available.

While there are many social factors in the spread of the epidemic that can be captured by various social science research methods, they coexist with biological factors. And it is difficult to say, as is the case in big western cities where social (for example economic precarity) or biological (ethnic belonging) factors prevail. Indeed, according to Anavaj Sakuntabhai, what also interests scientists is that the number of severe cases and the number of deaths are different depending on the ethnic group. Like other geneticists, he is very interested in knowing whether the genetic background of humans can explain this. It can be hypothesized that certain ethnicities are predisposed to severe cases and deaths from COVID-19. A recent study of human genetics showed that a region of chromosome 3, inherited from both father and mother, appeared to predispose to severe COVID-19 infection and death. And, currently, this segment of the genome is more prevalent in south Asia (India, Bangladesh), where you can see a lot of severe cases and deaths, but not in east Asia (Japan and China), where there is a very small percentage of this segment of the genome.

6 Epidemic, Collective Representations and Social Consequences

While researchers in the humanities and social sciences can rely on a whole range of statistical data to try to identify the social factors that, alongside the more purely biological factors, make it possible to identify the dynamic of the epidemic, they must also consider the collective representations that populations have of the disease. These representations obviously influence the way in which public health policies are received by these populations.

In times of epidemics, it is of course necessary to question the way in which the risk is perceived by the population. According to Samuel Benkimou, who is currently living in India, the political message of mobilization against the epidemic has to face the fact that a significant part of the population is not convinced that COVID-19 is a real threat. There is also a significant amount of doubt mixed with local beliefs and alternative medicines that coexist with official medical science, and religiously tinged messages that contribute to a somewhat blurred view of what constitutes the threat and what needs to be done. On the other hand, in rural areas, very few people are seen wearing masks because they are convinced that their difficult past will give them some form of resistance or perhaps cross-immunity with other diseases to which they have been exposed. While it has been said that in Japan it was the higher income people who seemed to be less afraid of the virus because they had easier access to medical care, in India it would be quite the opposite. People at the top of the social ladder protect themselves and can isolate themselves in closed residential communities, forbidden to all foreigners. In contrast, the majority of people from low-income backgrounds are more exposed. Since they often work in the informal sector—80% of people in India have no employment contract—they depend on their work for their livelihoods regardless of the threat and risks they may face. One audience member suggested another important factor that explains why wealthy people in Japan seem less cautious about the pandemic. The wealthiest people can afford to be tested—they have better access to testing than an ordinary worker. And this may be the reason why, in the first wave, there was a concentration of positive tests in the richest parts of Tokyo, as Rémi Scoccimarro has shown. But this may also be changing over time. The unions stress the importance of testing essential workers as well and asking employers to test their employees regularly, every two weeks.

For Rémi Scoccimaro, the phenomenon of stigma is important for understanding how different social groups react to the pandemic. This issue of stigma is critical in Japan for less affluent people, who need the support of their community. Indeed, once it is known that someone is infected within the community, they may face a very high level of stigma. In Japan, even nurses and doctors face this phenomenon. And if someone lives in a typical Japanese neighbourhood, where solidarity among people is very important, and if they lose the benefit of that solidarity, they lose a lot. So, in a way, that individual has no interest in getting tested or revealing that he has been infected and, especially, they take a lot of precautions not to get infected. This is something that wealthier people do not worry about as much because they can do without the community and they do not live in the same model of city. This issue of stigma is known in France, but in Japan it is something really structural. It also emerged for people who were irradiated after the Fukushima accident. The fear of stigma can be stronger than the fear of the virus itself. For example, some sick people who call an ambulance ask the ambulance to turn off its alarm so as not to alert the neighbourhood.

Adrienne Sala adds that the problem of high discrimination in Japan is also linked to the fact that there is less contamination, or at least known contamination, thanks to the PCR test. But in France for example, where there is a higher level of contamination and PCR testing, most people know infected people around them. This normality implies lower discrimination. For Anavaj Sakuntabhai, in Japan, the perception is still far from that of an ordinary disease. For Richard Paul, however, if everyone in France knows someone who has had COVID-19, there is still fear.

Another question raised is that of the Japanese relationship to hygiene. The high level of hygiene in Japan is often mentioned, for cultural or historical reasons, linked to the long-standing importance of hygiene policies. Nevertheless, Rémi Scoccimaro believes that we must be careful with cultural stereotypes that can be misleading. Japanese people are not uniformly more hygienic. He even points out that certain Japanese habits, such as the one for several people to take a bath successively without changing the water, are not particularly hygienic.

The human and social sciences not only highlight the social phenomena and representations that influence people's behaviour, such as proximity to a political party, membership of a social class, stigmatization, education, perception of risk, relationship to hygiene, but also certain consequences of the epidemic in society. Bernard Thomann reports a very worrying statistic in Japan at the moment: a suicide rate that is increasing for women much more than for men. Makoto Yano said that South Korea has a similar problem, but that he has not seen similar phenomena in other countries. In his opinion, this phenomenon is probably partly linked to the poor working conditions of many women, non-regular workers who are the priority victims of lay-offs. Rémi Scoccimarro adds that this is a surprising phenomenon given that the suicide rate in Japan has been decreasing for ten years. However, he created maps on suicide in Japan, and also after the Fukushima accident, and this allowed him to make some comparisons. In Asia, women are more suicidal than in other countries and this is a particular feature in Japan, Korea, Taiwan, and China. Especially in rural areas of China, the suicide rate of women is higher than in east Asian countries. The cause is not only professional; with the lockdown and telecommuting, the husband is more at home, which implies a greater burden on the wife. It may be interesting to find out in which part of Japan women commit suicide more. Usually, it is in the north, in the Akita prefecture, that the mental pressure on the group is the highest.

It seems that the curve is higher for women between 25 and 35 years old in Asia than it should be if we compare with other regions of the world. But it would be interesting to have other statistical elements, such as the profession of the person who committed suicide. Adrienne Sala adds that there is a child abuse prevention program in Japan that usually presents data on suicide of single mothers, which is very high compared to the general suicide rate. So during the crisis, like the health crisis that led to an economic crisis, it exacerbated the already existing trend in Japanese society. But these economic causes were exacerbated by the crisis and the lack of support from the government or other actors.

7 Information and Trust

Makoto Yano recalled that what was well demonstrated during the presentations and discussions was that from a social science perspective, taking into account culture and economic factors is important to study the behaviour of populations in the face of the epidemic. But what is also particularly important is how information is delivered in society. From this point of view, Makoto Yano thinks that politicians need to give a much clearer message. They have been very confused, at least in Japan he thinks, and he wonders if it has been the same in other countries—especially if you think about the “Go To Travel” campaign, which subsidized travel while at the same time many people were being advised not to travel.

The lack of trust in official statistics seems to be particularly high in Japan, as Rémi Scoccimarro points out. The general idea among the population is that if there are few cases in the archipelago, it is because there are so few tests. For Makoto Yano, in addition to the low number of tests, there are many people who do not want to go to hospital, especially if their condition is not really serious, especially since declaring oneself ill is a rather cumbersome process. As far as deaths are concerned, because the information is public, even if there is an underestimation, the possibilities of manipulating the information are relatively limited, according to him. Richard Paul points out that in other countries too the number of deaths officially recorded probably does not really reflect the real figures. What specialists rely on is the excess mortality figures for all causes among people over 60. If there is excess mortality, even if people have not been tested, these deaths are attributable to COVID-19.

This question of trust is also found in the adherence of the population to tracking applications. Bernard Thomann points out that, depending on the country, the download rate of tracking applications can be very different. For example, in Singapore or Iceland, some data show that about 40% of the population download these tracking applications. In France, the rate is only 3%, and Japan is in between these two extreme cases. According to Anavaj Sakuntabhai, there may be a reluctance to download the application since it is not clear what the consequences will be for oneself and one’s entourage if one is identified as a contact case. The official Japanese tracing application actually coexists with a multitude of applications developed, both locally and nationally, by citizens. It even happens, as Sophie Buhnik points out, that the authors of COVID-19 information sites work for local governments. These operators work voluntarily for the prefecture, and help the local government to disseminate information to citizens in a crisis context. But Adrienne Sala notes that, although civil society is very present today in informing the population, this movement is unfortunately counterbalanced by the lack of transparency in the decision-making process within the committee of experts linked to the Ministry of Health, Labour and Social Affairs.

According to Richard Paul, the implementation of tracking applications in Europe is also problematic and very confusing. The EU wanted a kind of universal application so that people coming from Italy, for example, could detect if they were a contact case for someone in France. However, according to Richard Paul, if we add to the European and national levels also the regional level, all these spatial discontinuities in terms of information, but also of political messages, of interventions make the situation chaotic. Moreover, as Sophie Buhnik also points out, the profusion of information raises another problem, that of the notion of infodemics—that is to say, an overload of information that makes it difficult to sort through all the available figures and causes fatigue in the population.

Another barrier is the digital divide, as one viewer noted in his question. However, Sophie Buhnik believes that even though programmers are mostly men, young Japanese women have as good a university education as their male counterparts, sometimes even better, and are equally capable of reading data. This digital divide could be about age difference; however, electronic literacy among people over 60 and 70 is about 50%, much better than in other countries. This divide can be to some extent geographical, with more urbanized departments having stronger collectives of programmers.

If a segment of the population is in an attitude of mistrust, it is because, as one contributor expressed it, we are in a period where multiple tools are being put in place to progressively follow the population and collect more and more information on individuals. For now, this is being done for health motivations, which still makes it acceptable to many. But is this not one more step in the direction of a control and surveillance society? Once we are out of the context of the epidemic and can think that these tools are no longer useful, will surveillance really stop? Especially, as Guillaume Ladmiral expresses it, we can legitimately ask ourselves if this intrusive technology is really necessary to fight the pandemic effectively. For example, there has been no mass surveillance or large-scale application in Japan and Taiwan, although the figures there are quite good.

The issue of trust in the context of the profusion of information applications on COVID-19 actually applies to all sorts of areas. Bernard Thomann believes that what is at stake is of course political, civil, and social citizenship, but also what social scientists and researchers are increasingly calling biological citizenship. There is a fear of citizens in the face of all the new technologies that can change their lives, or even their biological nature. What is very interesting, for example, is that people are afraid that these new messenger RNA vaccines will change our genetic makeup.

How people can trust or not trust these biopolitical policies really interacts with how not only the government, but also the scientific community, protects this biological citizenship. Anavaj Sakuntabhai asks Fumihiko Matsuda about the Nagahama city study presented during the workshop, how the authors of this study comply with data protection, ethics, and Japanese law. According to Fumihiko Matsuda, in Japan such a project must be submitted to the ethics committee for review, and this takes a long time. But it is clearly written in a government directive that if the study is urgent, it must go through the ethics committee, but in the case of Kyoto University Medical School, the dean or the president of the hospital can approve the study before getting approval from the ethics committee. So, if the dean or the president of the hospital thinks it is urgent and necessary and can be started quickly, the investigation can start. However, informed consent must be obtained from the participants. In the case of the Nagahama study, a questionnaire is sent out and, if the residents return it, it means that they are willing to participate in the study.

Anavaj Sakuntabhai MD, D.Phil. is a medical doctor from Thailand. After his Ph.D. on human molecular genetics at the Wellcome Trust Centre for Human Genetics, University of Oxford in 2000, he joined the Institut Pasteur to develop a programme on genetics of infectious diseases. He created the research unit of Functional Genetics of Infectious Diseases at Institut Pasteur in 2010 focusing on genetic susceptibility to dengue infection. He received Prix Dusquense in 2016 and i-Lab Grand Prix award from the French national challenge of innovation organized by the French Ministry of research in 2020 for development of new pentavalent dengue and Zika T cell vaccine. He coordinated European FP7 project on Dengue Framework for Resisting Epidemics in Europe (DENFREE). He was involved in investigating two recent global outbreaks of infectious diseases, Ebola and Zika. Currently, he is a coordinator of the Pasteur International Center for Research on Emerging Infectious Diseases (PICREID)—supported by the NIH. The project is implemented in west and central Africa and southeast Asia, linking large observational multicentre cohort studies with basic scientific research and leading to increased preparedness for new epidemic threats in the region. Recently, he was appointed as the director of Institut Pasteur Japan office to establish a transdisciplinary network on emerging infectious diseases between Japan, France, and countries in the Indo-Pacific region.

Bernard Thomann is an historian, Director of Institut français de recherches sur le Japon à la Maison franco-japonaise (MEAE/CNRS), and professor at the Institut National des Langues et Civilisation Orientales in Paris. He is a former visiting researcher at the University of Tokyo and visiting professor at the Tokyo University for Foreign Studies. His research interests include the history of health and social policies in modern and contemporary Japan, labour history, the history of occupational diseases, and the health and social history of the mining industry. His latest book is *La naissance de l'Etat social japonais: Biopolitique, travail et citoyenneté dans le Japon impérial (1868–1945)* (2015). He is scientific coordinator for the research programme funded by the French Agence Nationale de la Recherche (ANR): Growth and Forms of Employment: a Eurasian Comparison of Employment Insecurity (EURASEMPLOI) (2016–2022) and participated in the project "Transnational study of an exemplary occupational disease: silicosis and occupational health in France and the industrialised countries" (ANR "SANTE-ENVIRONNEMENT-TRAVAIL PROGRAMME (SEST)" 2007–2010).