

REVIEW

Risk compensation (Peltzman's effect) during the COVID-19 pandemic: a narrative review

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Abstract

Objective: The implementation of a safety measure can have counterproductive effects on other protective measures and people engage in risk compensatory behavior (fewer safety behaviors). It is essential to summarize different researches to better understand the dynamics of risk compensation during COVID-19 pandemic in order to develop evidence-based interventions. Mass vaccination and public use of facemasks, among others, had been widely adopted to halt COVID-19 pandemic. Given marked variability in vaccines effectiveness and the lack of evidence of facemask efficiency in preventing spread of infection, all preventive measures should be used as a single package. People might feel false sense of safety when engaging in any of these COVID-prevention behaviors, as predicted by risk compensation theory. this review aims to address the ongoing debate about risk compensation during COVID-19 pandemic; to summarize the findings of previous studies about it; and to provide new evidence base of the effects of a specific preventive measure on the other measures.

Methods: A structured search on PubMed and Google Scholar on January 8, 2024 for ever published articles in English using keywords in different combinations ("Peltzman effect" OR 'risk compensation' OR 'risk homeostasis') AND ('COVID19' OR 'COVID-19' OR 'covid19' OR 'covid-19' OR 'SARS CoV2' OR 'SARSCoV-2' OR 'SARS-CoV-2' OR 'SARS-COV2') AND ('face mask' OR 'face cover') AND ("distancing" OR social distancing") AND ("Vaccines" OR "Vaccination") AND ('hand hygiene') AND ('Sanitizers'). The search included various study designs including both observational and experimental studies.

Results: Studies showed conflicting results and no definite conclusion can be drawn about the risk compensation during COVID-19 pandemic.

Conclusion: Current literature failed to provide a solid evidence of risk compensation during the current pandemic. More community-based intervention studies are needed to provide solid bases for future pandemics.

Keywords: Peltzman Effect, Risk Compensation, Risk Homeostasis, COVID-19

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INTRODUCTION

World Health Organization (WHO) acknowledged the COVID-19 pandemic on 11 March 2020.¹ People who perceived the COVID-19 virus as threatening are more likely to adopt the recommended preventive measures, especially up-taking the vaccines.

Vaccination has played a key role in reducing the health burden of COVID-19, however, concern has been raised worldwide that risk compensation, a process whereby feelings of security arising from being vaccinated may lead people to reduce their engagement in other protective behaviours², could detract from the overall health benefit of the COVID-19 vaccination campaign.¹

Throughout the pandemic, the world has become familiar with the concept of risk compensation. In circumstances that are perceived as unsafe, people naturally modify their behavior, compensating to minimize that risk. The effects of risk compensation tend to fade over time as the personal threat decreases.² This is known as pandemic fatigue that is decreasing adherence to risk reduction strategies complicating public health efforts. Availability of vaccines further weaken adherence to other safety measures.² This phenomenon, in which individuals respond to safety measures with a compensatory increase in risky behavior, is named the “Peltzman Effect” first described it in 1975.^{2,3} The Peltzman’s phenomenon has been varying, identified in specific safety interventions but not others.² The famous example the use of pre-exposure prophylaxis to lower the risk of HIV transmission has been linked with diminished intention to wear condoms, greater numbers of sexual

partners, and increased occurrence of sexually transmitted infections in some studies.^{4,5}

Rationale

Although theoretically plausible, empirical evidence on risk compensation is mixed. There are many studies in different countries and dates with conflicting results about presence of risk compensation and its effects during COVID-19 pandemic.⁸ Risk compensation in response to government actions became a public issue. There is a need for further research to better know the dynamics of risk compensation during pandemics in order to develop evidence-based interventions to mitigate the potential negative consequences of Peltzman’s effect and to examine the presence of a risk compensation effect of one preventive measure on other measures.

Aim

To provide a short review on risk compensation and related terms and to summarize the findings of previous studies about risk compensation during COVID-19 pandemic.

METHOD

This study is a narrative review that summarizes results of previous publications regarding the theory of risk compensation and its presence during COVID-19 pandemic. A structured search on PubMed and Google Scholar on January 8, 2024 using the following search terms in different combinations (“Peltzman effect” OR ‘risk compensation’ OR ‘risk homeostasis’) AND (‘COVID19’ OR ‘COVID-19’ OR ‘covid19’ OR ‘covid-19’ OR ‘SARS CoV2’ OR ‘SARSCoV-2’ OR ‘SARS-CoV-2’ OR ‘SARS-COV2’) AND (‘face mask’ OR ‘face cover’) AND (“distancing”

OR social distancing”) AND (“Vaccines’ OR “Vaccination”) AND (‘hand hygiene’) AND (‘Sanitizers’). All previous English publications were included. We excluded case reports, case series, duplication, editorial and non-formal/personal notes. All other study designs were included if they consider the effect of one or more preventive measures on the other measures, whatever the target group. A total of 117 articles were downloaded, 60 of them were included in the review and 20 of them were found to have findings about risk compensation during COVID-19 pandemic.

RESULTS AND DISCUSSION

Peltzman effect

In 1975, Samuel Peltzman first described the phenomenon of compensating behavior (Peltzman effect, aka: risk compensation or risk homeostasis in epidemiology). This phenomenon has been used to explain the unintended consequences of a number of health care interventions³.

In his paper “The Effects of Automobile Safety Regulation,” Peltzman³ concluded that safety regulations like seatbelt laws did not affect highway death rates. Instead, the implementation of safety regulations led to riskier behavior from drivers. As a result, while driver death rates decreased, pedestrian death rates and property damage accidents increased.³ The basic premise of the theory is that people hold a specific target risk level or risk preference that they attempt to maintain. If a situation exceeds this target risk level, people engage in actions to lower the perceived risk. People likewise engage in risk-taking behaviors when the perceived risk is lower than their risk preference.² The external implementation of safety devices or

regulations can lead to a risk reduction (e.g., a seat belt protects the driver from serious accidents)³, causing people to feel safer, which then results in more risk-taking behavior².

There are confusion and debate among different specialties about the three terms Peltzman effect, risk compensation and risk homeostasis. Some scholars consider these terms to be synonymous while others consider they represent different ideas⁶.

The risk compensation theory (RCT) is a behavioral model of human attitudes towards risk which suggests that people might adjust their behavior in response to the perceived level of risk. The decrease in perceived risk through access to preventive measures may lead to increasing frequency of risky behaviors especially in the domain of health-related behaviors. The COVID-19 pandemic has exposed people to the sense of risk compensation and behavior change in response to the perceived risk. This results in false sense of safety and un-intended consequences. This phenomenon has been reported especially after mass vaccination with possible negative effects and effectiveness of vaccination programs.^{7,8}

Risk compensation has been investigated even before COVID-19 pandemic using different methods e.g., observational studies or natural experiments⁹, lab experiments¹⁰, self-report questionnaires¹¹, and population-level statistics.¹² These studies reported the presence of risk compensation and showed that it may not be universal and depend on the type of the behaviors and the intervention.

Risk homeostasis is a controversial hypothesis suggesting that people undertaking protective interventions are likely to exhibit increased

harmful behaviors and be exposed to higher risk. They compare the expected benefits and costs of safe behavior versus the expected benefits and cost of the risk behavior.⁶

Mechanism of risk compensation

There was an interaction between the multiple preventive measures that lead to risk compensation during COVID-19 pandemic. The mechanism of risk compensation includes both economic and psychological aspects. Economically safety can be perceived as a good, and thus traded for other more desirable goods.^{2,13}

Risk homeostasis theory explains the psychological aspect that is people reached desired level of risk, if this level is reduced by an intervention people will uptake other risks until they return to this tolerated risk level.¹³

Hedlund ² has identified four mental preconditions that play a role in risk compensation behavior: 1) the intervention must be visible; 2) there is a perception of protection, 3) motivation to increase risk-taking, and 4) control and opportunity to adjust behavior. A contributing factor is the effectiveness of the intervention on mutant strains. However, most of vaccines are protective against new mutants.¹⁴ All these criteria were meeting in the COVID-19 pandemic.¹⁵ The COVID-19 preventive measures are visible (e.g. vaccine uptake, wearing facemask, ..etc) and many people preceive these measures as protective so people adopt them. Pharmaceutical companies claimed the high effectiveness of different vaccines that encourage vaccinated persons to take the risk of neglecting other protective measures. Most of these measures are under perosnal control and are available

for all people.

Risk compensation and various preventive measures of COVID-19

Currently the COVID-19 preventive measures include mass vaccination as a specific measure and non-specific measures that pertinent to all respiratory infections e.g., facemask wearing, social distancing, lockdown, personal hygiene and use of sanitizers. All these strategies have focused on breaking the chain of virus transmission. All preventive measures should be taken as a single package for effective control of COVID-19 at community level. It is not clear whether the simultaneous adoption of all preventive measures is additive or multiplicative in effects. To the best authors' knowledge there is no literature to support the effects of simultaneous or combined use of different preventive measures.

(1)COVID-19 vaccines

Efficacy of COVID-19 vaccines varies and all vaccines give neither immediate nor full protection. However, over-confidence in vaccines gives a sense of personal safety and is associated with increasing in risky behavior by neglecting other non-specific preventive measures including facemask use, distancing and hand hygiene. The vaccinated individuals could still become infected and transmit the virus and its variants.¹⁶ An epidemiological study showed that the probability of COVID-19 positivity increased after the first dose of the vaccine,¹⁷ Ioannidis,¹⁸ in his mathematical model concluded that risk compensation may eliminate the benefits of COVID-19 vaccines, especially with low vaccine effectiveness and/or low probability of infection in population.

(2)Facemask wearing

Wearing facemask correctly in closed spaces was recommended to decrease transmission of COVID-19 viruses. There is uncertainty about the size of effects of face coverings in the package of measures for reducing transmission. Evidence from laboratory and community experiments as well as observational studies justifies the use of facemask.^{19,20,21} Mask wearing may encourage people to neglect other preventive measures and increases the risks for transmission and reduces its benefits.²² It is recommended to wear facemasks with other preventive measures because their minimal risks and substantial effects.²³

(3)Social distancing and avoiding physical contact

Social or physical distancing from others cut the chain of transmission of infectious diseases including COVID-19.²⁴ The distance specified to be six feet (about two meters) at least.²⁵ Physical distancing includes shielding and avoiding gatherings and crowd, shaking hands, hugging and kissing.²⁶ Early social distancing has substantial impact on the number of infected individuals and deaths by COVID-19 and is dependent upon demographic, environmental, behavioral and economic dimensions.²⁷

(4)Lockdown (mobility limitation)/ quarantine

The lockdown, quarantine and mobility restrictions are special types of social distancing enforced by governments to halt the COVID-19 pandemic. These include closure of non-vital services and retail shops as well as precautionary measures at work and in educational settings.²⁸

Many studies concluded that the pandemic

can be curbed by lockdown in different countries.^{29,30,31} Furthermore, some scholars postulated that lockdown affects the environment, people's psychology, and economy.²⁹ Some studies reported no effect of lockdown on morbidity and mortality of COVID-19 and recommended the economy-friendly relaxed control measures to prevent the adverse effect on mental health and quality of life associated with lockdown fatigue and increased mortality from other causes e.g., myocardial infarction, suicide, and stroke.^{32,33}

For lockdown to be effective it should be applied in a large scale and very early in the pandemic associated with other control measures after assurance of people's solidarity as well as adherence to the necessary changes through information, education and communication (IEC).^{32,34} Cost-benefit analysis should be considered before enforcing lockdown for future pandemic.³⁵

(5)Personal hygiene and use of sanitizers

During the COVID-19 pandemic, personal hygiene and sanitizers use were advocated and promoted to prevent the spread of infection together with other measures.³⁶ These included thorough cleaning of hands either with 60% alcohol-based rub or soap and water, cover mouth and nose by a tissue when coughing or sneezing, dispose tissue into closed bin, and disinfect regularly touched surfaces e.g., door handles, phone screens and faucets.^{37,38,39} The challenges of these measures in developing countries are high population density, low hand washing facilities, air pollution, lack of access to clean water as well as limited personal protective equipment. The correct and sound use of disinfectants and sanitizers is important to avoid their adverse effects on the humans, animals, and environment.^{40,41}

Table 1. Summary of risk compensation in different COVID-19 preventive measures.						
Author & Year	Study design	Country/setting	Population	Protective measure	Effect on other measures	Risk compensation
Chen et al. (42)	Cross-section	China, hospital	544 COVID-19 inpatients grade III	Vaccination	More hand-washing & mask wearing after vaccination than prior to it. -Significant lower % of wearing masks and hand washing in non-vaccinated group	No
Hall et al. (8)	Cross-section	Canada	1958 general population		Vaccinated are more likely to perform distancing, mask wearing and hand hygiene than unvaccinated.	No
Yang et al. (43)	Online survey	China	602 travellers		No significant differences in hand washing and mask wearing among travellers. These measures partly improved among vaccinated.	No
Hale et al. (44)	Cross-section	12 European countries	754 (2 periods) Oxford COVID-19 Government Response Tracker		No reduction in distancing or mask use	No
Wambua et al. (45)	Cross-section	16 European countries	29292 general population		More social contacts	Yes
Desrichard et al. (16)	Longitudinal study	UK	765 general population		14 precautionary measures	No
Wright et al. (46)	Longitudinal study	UK	70,000 adults		General precautionary measures & social distancing	No
Hwang et al. (47)	Panel data + cross-section	South Korea	Daily vaccines, credit cards, airline companies, survey (4980 subjects)		Shopping, travel & socialization	No
Agrawal et al. (48)	National panel data	USA	122,405 observations		Mask, hand washing, avoiding crowds and restaurants	No
Oliver et al. (49)	Observational cross-section	USA	2,068 general population		Social distancing	No
Seres et al. (50)	Randomized field experiment	Germany	Joining lines in front of stores		Social distancing	No
Aranguren et al. (51)	Field experiment	France	>4500 real-life interaction		Distancing	Yes
Kovacs et al. (52)	Ecologic study	Germany	geo-located smartphone data.		Social mobility	Yes
Luckman et al. (7)	Two online scenarios	UK	401 & 400 general population	Facemask	Participants would stand, sit, or walk closer to the stranger if either of them was wearing a mask.	Yes
Wadud et al. (53)	Record-based	Bangladesh.	Daily mobility & COVID-19 cases records		Significant increases in community mobility and decreases in stay at home associated with increases in new COVID-19 cases.	Yes
Jorgensen et al. (54)	Quasi-experimental	Denmark	106,880 General population		Decrease in close contact. No effect on hygiene	Yes (close contact) No (hygiene)
Yan et al. (55)	Quasi-experimental	USA	Daily SafeGraph smart device location data and variation in the date of face mask mandates		Less time at homes and more visits to high-risk location	Yes
Aranguren (56)	Cross-section observational	France (Paris)	1396 & 1326 pediatsterns (2 waves)		Men: less distancing Women: distancing in one wave	Yes (men) No (women)
Guenther et al. (57)	Cross-section	UK	1254 general population	Lockdown	Increase mask use & distancing	No
Henk et al. (58)	Longitudinal	Germany	989 general population	Quarantine & face masks	Less distancing	Yes

Table 1 summarizes the risk compensation of each preventive measure on the other measures in different studies. Twenty studies explored risk compensation. It is clear that the majority of studies are cross-sectional in design (50%; 10 out of 20) done in general population of Europe, USA and Canada (80%; 16 out of 20); three are longitudinal, two quasi-experimental and only one field trial. Risk compensation was studied mostly for vaccination (50%; 10 out of 20) and facemask (50%; 10 out of 20) as these are the most commonly adopted measures. Risk compensation behavior was reported in 40% (8 out of 20) of studies retrieved. Few studies were done in developing countries (25%, 5 out of 20) where the situation may be worse than developed countries.^{42,43,47,53}

Effects of risk compensation

Risk compensation phenomenon reverses the benefits of different COVID-19 preventive measures, especially if each intervention is not sufficiently effective when used alone in real life or among high-risk groups. Witnessing someone else taking a precaution could potentially increase one's possibility of taking a risk e.g., who have not received a COVID-19 vaccine may, consciously or subconsciously, neglect facemasks and distancing as long as others received the vaccine. This could be potentially disastrous resulting in a higher disease burden.⁵⁹

How to overcome risk compensation?

For counteracting and neutralizing the false believe leading to risk compensation it is important to recognize and be aware of its existence in the community. Public campaign of IEC (information, education and communication) should be carried

out by the mass media, government and medical personnel to reinforce all preventive measures to be tackled as a single package.⁶⁰ The public health messages should be clear, reliable, straightforward, and feasible.

Risk compensation in COVID-19 varies from population to another and within different strata of the same population depending on risk perception and level of adherence with public health measures.¹⁵ Counteracting the widespread misinformation (infodemic) should be a component of COVID-19 control program.

Limitations and biases

A limitation of this narrative review is the contradictory findings regarding risk compensation during the COVID-19 pandemic in the included studies. There is no standardization of research designs, most of them are descriptive in nature with self-reported answers that introduce recall bias and/or social desirability impage. Also studies were done on different populations and different dates.

CONCLUSION

This brief narrative review revealed that several amounts and types of risk compensation have occurred in response to some preventive measures but not in reaction to others. Studies showed conflicting results and no definite conclusion can be drawn.

Alertness of risk compensation counteracts the false believes and practices. It is important to implement all preventive measures as a single package to augment each other including vaccination, facemask wearing, physical and social distancing and sanitizers use.

Risk compensation is more likely to be reported in observational rather than experimental studies with conflicting results and higher risk of bias. There is a need for social and behavioral longitudinal research, especially in developing countries, to map risk compensation types and at high-risk groups to tackle this phenomenon as COVID-19 is still existing.

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REFERENCES

1. WHO Director-General's opening remarks at the media briefing on COVID19 -March 2020. Available at: <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---21-december-2020> Accessed: January 8, 2024 Accessed: January 8, 2024.
2. Hedlund J. Risky business: safety regulations, risks compensation, and individual behavior. *Inj Prev.* 2000;6:82-90.
3. Peltzman S. The effects of automobile safety regulation. *Journal of Political Economy.* 1975;83:677-725.
4. Traeger MW, Cornelisse VJ, Asselin J, Price B, Roth JN, Willcox J, et al; PrEPX Study Team. Association of HIV preexposure prophylaxis with incidence of sexually transmitted infections among individuals at high risk of HIV infection. *JAMA.* 2019;321:1380-1390.
5. Golub SA, Kowalczyk W, Weinberger CL, Parsons J. Preexposure prophylaxis and predicted condom use among high-risk men who have sex with men. *J Acquir Immune Defic Syndr.* 2010;54:548-55.

6. Pless B. Risk Compensation: Revisited and rebutted. *Safety* 2016; 2:16.
7. Luckman A, Zeitoun H, Isoni A, Loomes G, Vlaev I, Powdthavee N, Read D. Risk Compensation During COVID-19: The Impact of Face Mask Usage on Social Distancing. *Journal of Experimental Psychology: Applied.* 2021;27(4):722–738.
8. Hall P, Meng G, Sakib M, Quah A, Agar T, Fong G. Do the vaccinated perform less distancing, mask wearing and hand hygiene? A test of the risk compensation hypothesis in a representative sample during the COVID-19 pandemic. 2023;41:4027–4030.
9. Radun I, Radun J, Esmailikia M, Lajunen T. Risk compensation and bicycle helmets: A false conclusion and uncritical citations. *Transportation Research Part F: Traffic Psychology and Behaviour,* 2018;58:548–555.
10. Phillips O, Fyhri A, Sagberg F. Risk compensation and bicycle helmets. *Risk Analysis.* 2011;31(8):1187–1195.
11. Marcus J, Glidden D, Mayer H, Liu Y, Buchbinder P, Rivet Amico K, et al. No evidence of sexual risk compensation in the iPrEx trial of daily oral HIV preexposure prophylaxis. *PLOS ONE,* 2013;8(12), Article e81997.
12. McCarthy P, Talley W. Evidence on risk compensation and safety behaviour. *Economics Letters,* 1999;62(1):91–96.
13. Underhill, K. Study designs for identifying risk compensation behavior among users of biomedical HIV prevention technologies: Balancing methodological rigor and research ethics. *Social Science & Medicine.* 2013;94:115–123.
14. Wu N, Joyal-Desmarais K, Ribeiro PAB, Vieira AM, Stojanovic J, Sanuade C, et al. Long-term effectiveness of COVID-19 vaccines against infections, hospitalizations, and mortality in adults: findings from a rapid living systematic evidence synthesis and meta-analysis up to December, 2022. *Lancet Respir Med.* 2023;11(5):439-452.
15. Trogen B, Caplan A. Risk Compensation and COVID-19 Vaccines. *Ann Intern Med.* 2021;174(6):858-859.
16. Desrichard O, Moussaoui L, Ofosu, N. Reduction of Precautionary Behaviour following Vaccination against COVID-19: A Test on a British Cohort. *Vaccines* 2022, 10,936.
17. Bernal J, Nick Andrews N, Gower C, Robertson C, Stowe J, Tessier E, et al. Effectiveness of the Pfizer-BioNTech and Oxford-AstraZeneca vaccines on covid-19 related symptoms, hospital admissions, and mortality in older adults in England: test negative case-control study. *BMJ* 2021;373:n1088

18. Ioannidis J. Benefit of COVID-19 Vaccination Accounting for Potential Risk. *npj Vaccines* 2021;6:99.
19. Mitze T, Kosfeld R, Rode J, Walde K. Face masks considerably reduce COVID-19 cases in Germany. *Proc Natl Acad Sci USA* 2020;117:32293–301.
20. Karaivanov A, Lu SE, Shigeoka H, Chen C, Pamplona S. Face masks, public policies and slowing the spread of COVID-19: evidence from Canada. *J Health Econ* 2021;78:102475.
21. Howard J, Huang A, Li Z, Tufekci Z, Zdimal V, van der Westhuizen HM. An evidence review of face masks against COVID-19. *Proc Natl Acad Sci USA* 2021;118(4):e2014564118
22. WHO. Coronavirus Disease 2019 (COVID-19): How to protect yourself & others. Centers for Disease Control and Prevention. 2020. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html>. Accessed January 8, 2024.
23. Greenhalgh T, Schmid MB, Czypionka T, Bassler D, Gruer L. Face masks for the public during the covid-19 crisis. *BMJ* 2020;369(m1435)
24. Moosa I. The effectiveness of social distancing in containing Covid-19. *Appl. Econ.* 2020;52(58):6292–6305.
25. Setti L, Passarini F, De Gennaro G, Barbieri P, Perrone M, Borelli M. Airborne transmission route of covid-19: why 2 meters/6 feet of inter-personal distance could not be enough. *Int. J. Environ. Res. Public Health* 2020;17(8):2932.
26. Sewpaul R, Mabaso M, Cloete A, Dukhi N, Naidoo I, Davids A. Social distancing behaviour: avoidance of physical contact and related determinants among South Africans: twelve days into the COVID-19 lockdown, *Psychology, Health Medicine*.2023;28(1):260-278.
27. Prakash N, Srivastava B, Singh S, Sharma S, Jain S. Effectiveness of social distancing interventions in containing COVID-19 incidence: International evidence using Kalman filter. *Economics and Human Biology* 2022;44:101091
28. UNICEF. Preventing a 'lockdown generation' in Europe and central Asia Building resilient societies with young people in the era of COVID-19.2020 United Nations Children's Fund (UNICEF) and European Training Foundation (ETF). 2020 <https://www.etf.europa.eu/en/publications-and-resources/publications/preventing-lockdown-generation-europe-and-central-asia> Accessed: January 8, 2024
29. Atalan A. Is the lockdown important to prevent the COVID-19 pandemic? Effects on psychology, environment and economy-perspective. *Ann Med Surg (Lond)*. 2020;56:38-42.
30. Houvèssou G, de Souza T, da Silveira M. Lockdown-type containment measures for COVID-19 prevention and control: a descriptive ecological study with data from South Africa, Germany, Brazil, Spain, United States, Italy and New Zealand, February – August 2020. *Epidemiol. Serv. Saude, Brasília*, 2021;30(1):e2020513.
31. Yang X. Does city lockdown prevent the spread of COVID-19? New evidence from the psynthetic control method. *Global Health Research and Policy*. 2021;6:20.
32. Fuss F, Weizman Y, Tan A. COVID-19 Pandemic: How Effective Are Preventive Control Measures and Is a Complete Lockdown Justified? A Comparison of Countries and States. *COVID* 2022;2:18–46.
33. Musoke D, Nalinya S, Lubega GB, Deane K, Ekirapa-Kiracho E, McCoy D (2023) The effects of COVID-19 lockdown measures on health and healthcare services in Uganda. *PLOS Glob Public Health* 2023;3(1):e0001494.
34. Girus T, Lentiro K, Geremew M, Migora B, Shewamare S, Shimbire M. Optimal strategies for COVID-19 prevention from global evidence achieved through social distancing, stay at home, travel restriction and lockdown: a systematic Review. *Archives of Public Health* 2021;79:150.
35. Yanovskiy M, Socol Y. Are Lockdowns Effective in Managing Pandemics? *Int. J. Environ. Res. Public Health* 2022;19:9295.
36. Alandry G. Frequent hand washing with soap is one of the most effective ways to stop the spread of coronavirus (COVID-19). *WaterAid*. 2020. Available from: <https://washmatters.wateraid.org/water-and-hygiene-against-coronavirus> Accessed: January 8, 2024
37. CDC. Coronavirus Disease 2019 (COVID-19): How to protect yourself & others. Centers for Disease Control and Prevention. 2019 Available at: <https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html>. Accessed: January 8, 2024
38. WHO. Mask use in the context of COVID-19: interim guidance. Report No.: WHO/2019-nCoV/IPC_Masks/2020.5. World Health Organization, 2020. [https://www.who.int/publications/i/item/advice-on-the-use-of-masks-in-the-community-during-home-care-and-in-healthcare-settings-in-the-context-of-the-novel-coronavirus-\(2019-ncov\)-outbreak](https://www.who.int/publications/i/item/advice-on-the-use-of-masks-in-the-community-during-home-care-and-in-healthcare-settings-in-the-context-of-the-novel-coronavirus-(2019-ncov)-outbreak). Access: January 8, 2024
39. Rachel A. Leslie, S. Steve Zhou, David R. Macinga Inactivation of SARS-CoV-2 by commercially available alcohol-based hand Sanitizers. *American Journal of Infection Control* 2021;49:401–402.

40. Dhama K, Patel S, Kumar R, Masand R, Rana J, Yatoo M, Tiwari R. The role of disinfectants and sanitizers during COVID-19 pandemic: advantages and deleterious effects on humans and the environment. *Environmental Science and Pollution Research* 2021;28:34211–34228
41. Prajapati P, Desai H, Chandarana C. Hand sanitizers as a preventive measure in COVID-19 pandemic, its characteristics, and harmful effects: a review. *Journal of the Egyptian Public Health Association* 2022;97:6
42. Chen L, Tung TH, Zhang X, Wang G. Applicability of risk compensation to the relationship between health behaviors and COVID-19 vaccination among inpatients in Taizhou, China. *Z Gesundh Wiss. (Journal of public health)* 2023; March 15:1-7.
43. Yang M, Wang L; Xu L; Ke M, Sun L. Health Behaviours among Travellers Regarding Risk Compensation Following COVID-19 Vaccination in Taizhou, China. *Can J Infect Dis Med Microbiol* 2023:1329291.
44. Hale T, Angrist N, Goldszmidt R, Kira B, Petherick A, Phillips T. A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker). *Nat Hum Behav.* 2021;5(4):529-538.
45. Wambua J, Loedy N, Jarvis C, Wong K, Faes C, Grah R et al. The influence of COVID-19 risk perception and vaccination status on the number of social contacts across Europe: insights from the CoMix study. *BMC Public Health* 2023;23:1350
46. Wright L, Steptoe, A.; Mak, H.W.; Fancourt, D. Do People Reduce Compliance with COVID-19 Guidelines Following Vaccination? A Longitudinal Analysis of Matched UK Adults. *J. Epidemiol. Community Health* 2022;76:109–115.
47. Hwang J, Hwang S, Kim H, Lee J, Lee J. Testing Risk Compensation: Evidence from COVID-19 Vaccination. June 12, 2023. HKUST Business School Research Paper No. 2023-104. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4404558. Accessed: January 8, 2024
48. Agrawal V, Sood N, Whaley CM. The ex-ante moral hazard effects of COVID-19 vaccines. Technical report, National Bureau of Economic Research. NBER Working Paper No. 30602. October 2022. https://www.nber.org/system/files/working_papers/w30602/w30602.pdf Accessed: January 8, 2024
49. Oliver M. Facemask Wearing and Social Distancing: A Test of Risk Compensation Theory. *Virginia Journal of Business, Technology, and Science.* 2021;1(1).
50. Seres G, Balleyer A, Cerutti N, Danilov A, Friedrichsen J, Liu Y, et al. Face masks increase compliance with physical distancing recommendations during the COVID-19 pandemic. *Journal of the Economic Science Association* 2021;7:139-158.
51. Aranguren M. Face mask use conditionally decreases compliance with physical distancing rules against COVID-19: gender differences in risk compensation pattern. *Ann. Behav. Med.* 2022;56:332–346.
52. Kovacs R, Dunaiski M, Tukiainen J. The effect of compulsory face mask policies on community mobility in Germany. *Scand. J. of Economics* 2023;125(4):1027–1055.
53. Wadud Z, Rahman SM, Enam A. Face mask mandates and risk compensation: an analysis of mobility data during the COVID-19 pandemic in Bangladesh. *BMJ Global Health* 2022;7:e006803.
54. Jorgensen F, Lindholt M, Bor A, Petersen M. Does face mask use elicit risk-compensation? Quasi-experimental evidence from Denmark during the SARS-CoV-2 pandemic. *Eur J Public Health* 2021;31(6):1259-1265.
55. Yan Y, Bayham J, Richter A, Fenichel E. Risk compensation and face mask mandates during the COVID-19 pandemic. *Scientific Reports* 2021;11:3174
56. Aranguren M, Cartaud A, Cisse I, Coello Y. People interact closer when a face mask is worn but risk compensation is at best partial. *European Journal of Public Health*, 2023;33(3):1177–1182.
57. Guenther B, Galizzi MM, Sanders JG. Heterogeneity in risk-taking during the COVID-19 pandemic: Evidence from the UK lockdown. *Front Psychol* 2021;12:643653.
58. Henk K, Rosing F, Wolff F, Frenzel S, van Dick R, Erkens V, et al. An examination and extension of the Peltzman effect during the Covid-19 pandemic. *Current Research in Ecological and Social Psychology.* 2023;4:100091
59. Kim JH, Marks F, Clemens JD. Looking beyond COVID-19 vaccine phase 3 trials. *Nat Med.* 2021;27:205-211.
60. Iyengar K, Ish P, Botchu R, Jain V, Vaishya R. Influence of the Peltzman effect on the recurrent COVID-19 waves in Europe. *Postgrad Med J* 2022;98:e110–e111.