

UNDER HUMANITARIAN LOGISTICS, THE RELATIONSHIP BETWEEN DISASTERS AND LOGISTIC PERFORMANCE

*Jahel Xie, Polin Lai**

1 Department of International Trade and

Logistics, Chung-Ang University, Seoul 06974, Republic of Korea ; ee44923219@cau.ac.kr 2

Correspondence: polin@cau.ac.kr

ABSTRACT

Purpose: The impact of COVID-19 pandemic goes beyond its direct impact on health and far-reaching effects on the economy, society, and mental health globally, while the likelihood of other serious infectious disease like the COVID-19 pandemic occurring has increased. The World Development Index emphasizing that the ultimate goal of development should be to enhance human well-being. Therefore, this study quantitatively analyzes the relationship between humanitarian logistics (HL) performance and disaster response in the context of the COVID-19 pandemic, aiming to explore three key relationships: 1) the relationship between logistics performance and the control and spread of the epidemic; 2) the relationship between the World Development Index and the self-construction of logistics performance; and 3) the relationship between the World Development Index and the control and spread of the epidemic.

Design/methodology/approach: Correlation analysis and regression analysis were used to conduct correlation analysis on the logistics performance index, the world development index, and the number of epidemic infections and deaths.

Findings: This study is based on the theoretical guidance of Sustainable Development Goal 3: Good Health and Well-being. Conducting a combined empirical and applied study of basic epidemic and logistics data. The results show that developed countries with better logistics had faster vaccine adoption but still have higher infection rates, with correlation with strong Foreign Direct Investment (FDI). While Geographic locations and Urban population (UP) play significant roles to determine the rate of COVID-19 deaths. Encouraging knowledge cooperation and independent development, putting forward four logistics-centered epidemic prevention and control suggestions.

Originality/value: This study outlines the potential global index associations of logistics performance under the COVID-19 pandemic and how these changes affect the number of infections and deaths from the pandemic. It also provides insights into the participation of different countries in the global supply chain and points out future research directions.

Keywords: Humanitarian logistics (HL); COVID-19 pandemic; Vaccine; Supply chain management; World development indicators.

1. Introduction

Over the past few decades, the world has faced multiple pandemics caused by various pathogens, with a rising frequency of new infectious organism strains (Priyadarisni et al., 2020). On average, a new infectious disease impacting humans emerges every eight months, with more than 35 Emerging Infectious Diseases affecting people since 1980 (Straif-Bourgeois et al., 2023). The recent COVID-19 pandemic has sparked global concern, with WHO reporting approximately 0.78 billion cases worldwide out of a population of 7.80 billion (World Health Organization, 2024). Nearly one in ten individuals has been affected by this global health crisis, which has severe implications on human health (Priya et al., 2022). Initially declared a global public health emergency by WHO and later categorized as a pandemic crisis (Sohrabi et al., 2020). While the burgeoning definition of HL is: The logistics and supply chain management focusing on the preparation for, response to, and recovery from a humanitarian crisis, with the aim of saving lives and alleviating the suffering of affected populations (Kembro et al., 2024).

Humanitarian logistics (HL) cooperation in the context of global cooperation is important. While international aid organizations like United States Agency for International Development (USAID) have invested in logistical projects for epidemic control, challenges remain in effective response to pandemics (Kuznetsova, 2020), although the levels of development in different parts of the world differ markedly, but cooperation between countries is vital during global health crises, necessitating innovative approaches for evaluating HL performance on an international scale. However, there are currently few widely accepted methods developed by the scientific community that specifically take into account the HL in a worldwide aspect (Karuppiiah et al., 2021). When consider about HL, geographic variability is essential for proper planning and resource allocation in HL, underscoring the need for a holistic evaluation framework.

From the perspective of individual countries, COVID-19 pandemic prompted countries to implement various measures such as enhanced hygiene practices, movement restrictions, social distancing, mask-wearing mandates, work stoppages, and school closures (Fang et al., 2020). Despite with that kind of pandemic's impact, the worldwide logistics delivery market is projected to expand at a compound yearly growth rate of 8.5% from 2022 to 2027 (Melton, 2022). This world-class disaster intertwined with various facets of logistics, from efficiently transferring patients to temporary hospitals to delivering relief items and essential supplies, from keeping multinationals trading to satisfying a variety of consumers' needs. Simultaneously, nations accelerated vaccine development to achieve mass immunization. Although vaccine distribution aided in curbing the outbreak, it also underscored challenges in infection caused by the return to work after vaccine, so there is also a potential correlation between spread and World Development Indicators (Hunter et al., 2020), which have potential links to HL (Vallancourt & Haavisto, 2016).

As the weekly report from WHO, the total COVID-19 cases are regressing to early epidemic levels, suggesting the end of the epidemic. The plethora of literature on epidemic supply chain management underscores the necessity for global cooperation in combatting disasters. However, validating the conclusions of past agent-based simulation studies requires additional empirical investigations. This study seeks to empirically analyze how logistics performance has influenced epidemic control efforts during the COVID-19 pandemic in a global aspect, and to evaluate the alignment of current logistics operations with the needs of HL.

The remainder of the study is structured as follows: in Section 2 some key concepts of HL and existing literature in the context of COVID-19 pandemic are outline. Section 3 provides an overview of the research methodology utilized for the purposes of the review and the boundaries of our study. In Section 4 deals with the analysis and validate of the selected literature regarding HL and epidemic control. Section 5 give some feasible suggestion along with the main findings of this study. Finally, the study ends with some concluding remarks and suggestions for future study.

2. Literature review

2.1 Epidemics and logistics performance

The interconnection between epidemics and logistics performance is evident in the global dissemination of diseases facilitated by travel, migration, and trade in plants and animals (Baker et al., 2022). Travel as a core part of transportation close related to logistic. In the early stages of the COVID-19 outbreak, despite stringent travel lockdown policies in China, there was a notable probability of exported cases, although with approximately 70.5% being avoided (Wells et al., 2020). Migrant populations in the EU/EEA are crucial in preventing disease outbreaks, emphasizing the significance of vaccination in enhancing immunity and reducing infectious disease incidence (Deal et al., 2021). However, COVID-19 is caused by the novel coronavirus SARS-CoV-2, which was a new virus that wasn't included in the existing vaccine, developing a new vaccine involves several phases of rigorous testing to ensure safety and efficacy, even now the outbreak is almost over, still have new study into revolutionary SARS-CoV-2 vaccine approaches (Edalat et al., 2024). The urgency of the pandemic

spurred unprecedented collaboration among scientists, researchers, governments, and pharmaceutical companies, but when vaccine real application, the coordinating efforts across different organizations and countries still took time (Lendacki et al., 2024). Swan indicated the faster the vaccine getting, the lower the number of people infected (Swan et al., 2021); partially highlighted the impact of Logistics Performance Index (LPI), especially its timeliness sub-component, on minimizing national casualties. Trade in plants and animals, a widespread international trade, closely aligns with logistics. Despite entry-exit inspection and quarantine measures ensuring safety, instances of COVID-19 transmission through traded fresh meat demonstrate how international logistics contribute to disease spread (Bachofen, 2018). At the same time, previous studies have found that the smaller urbanization, the fewer infection cases (Yu et al., 2021), the higher urbanization, the higher the Logistics performance Index (LPI) (Tian et al., 2022). Less developed regions will have slower access to vaccines, but their drivers like climate change, population density, urbanization and foreign trade (serve as catalysts for the acceleration of pandemic incidents) relatively small (Duroseau et al., 2023). So, examining the influence of Logistics Performance Index (LPI) on epidemic spread raises significant questions.

Previous studies have predominantly focused on the relationship between LPI and environmental pollution, with environmental sustainability being a key research domain in humanitarian logistics. Ouni and Ben Abdallah (2024) summarized indicators relevant to environmental factors: Gross Domestic Product (GDP), Foreign Direct Investments (FDI), Renewable Energy Consumption (REC), Green Innovation (GRI), Trade Openness (TO) and Transport Carbon dioxide Emissions (TCO₂) (Ouni & Ben Abdallah, 2024), which nearly covered all indicators that have association between Green Logistic (GRL) and environmental degradation. While research typically spans from 2007 to 2018 due to data availability limitations during the COVID-19 pandemic (2018-2022). But the research region as an innovation has been explained in great detail, as big as a continent (Jo Storto & Evangelista, 2023) or as small as a country (Nayak et al., 2024), classification by high perform group: top 25 ranked LPI countries (Magazzino et al., 2021) is a novel. The results are different in various time periods with all kinds of study areas, but the common of these studies are that the variables are strongly correlated with environmental and logistics performance.

Investigations considering high performing LPI countries also offer insights into how variables such as Gross Domestic Product (GDP), Foreign Direct Investments (FDI), Renewable Energy Consumption (REC), Green Innovation (GRI), Trade Openness (TO), and Transport Carbon Dioxide Emissions (TCO₂) influence environmental and logistics performance (Zhang, 2022). These factors, critical in pandemic acceleration, raise questions about their role in epidemic spread and the environmental impact within a logistic context.

2.2 Relationship between epidemics and logistics performance

The interconnection between epidemics and logistics performance is evident in the global dissemination of diseases facilitated by travel, migration, and trade in plants and animals (Baker et al., 2022). Travel as a core part of transportation close related to logistic. In the early stages of the COVID-19 outbreak, despite stringent travel lockdown policies in China, there was a notable probability of exported cases, although with approximately 70.5% being avoided (Wells et al., 2020). A widespread international trade, including plants and animals, is closely aligns with logistics. Despite entry-exit inspection and quarantine measures ensuring safety, instances of COVID-19 pandemic transmission through traded fresh meat demonstrate how international logistics contribute to disease spread (Bachofen, 2018). The timeliness of logistics, logistics transit, and the movement and contact of logistics personnel all increase the spread of the epidemic. Hohenstein combined an extensive literature review with a multiple-case study of 10 internationally operating logistics service providers and give a summary to the method of handling the impact of the COVID-19 pandemic (Hohenstein, 2022).

On the other hand, the performance of logistics will help to reduce the spread of the epidemic and the infection rate of people. Emergency logistics has emerged as a critical component of disaster relief and mitigation, providing essential material support to safeguard the lives and well-being of affected populations. The prompt and efficient delivery of emergency supplies to disaster-stricken areas is pivotal in minimizing the overall impact of disasters, particularly in mitigating secondary damage in the aftermath (Zhang et al., 2022). Therefore, designing an effective management model to modify the operations of logistics networks is considered one of the most significant management challenges under the critical circumstances of epidemic outbreaks (Mostafaei Damian & Farughi, 2022). From production and transportation to storage and medical facilities, the vaccines require specialized end-to-end cold chain logistics. Swan indicated the faster the vaccine getting, the lower the number of people infected (Swan et al., 2021), highlighted the impact of Logistics Performance Index (LPI), especially its timeliness sub-component, on minimizing national casualties. Fahmi based on the PRISMA-ScR 2018 checklist summarized an efficient and resilient vaccine supply chain conceptual framework (Fahmi et al., 2022). Wang proposed a two-stage stochastic model for emergency supply planning, under the case of West China Hospital coalition of Sichuan Province proved that the cooperation within both pre-disaster emergency supply pre-positioning and post-disaster transshipment and procurement have significantly enhanced. Effectively saved total cost and reduced the maximum supply shortage rate (Wang et al., 2022). At the same time, the problem of reverse logistics network design for effective management of medical waste in epidemic outbreaks also attracting attention. Kargar proposed a linear programming model with three objective functions is proposed to minimize total costs, reduce the risks associated with the transportation and treatment of infectious medical waste, and limit the maximum amount of uncollected waste in medical waste generation center (Kargar et al., 2020).

2.3 Relationship between epidemics and world development indicators

Some world development indicators also point to logistics helping to spread the disease. Less developed regions will have slower access to vaccines, but their drivers like climate change, population density, urbanization and foreign trade (serve as catalysts for the acceleration of pandemic incidents) relatively small (Duroseau et al., 2023). Khazaei uses the bivariate correlation method evaluated that significant positive correlation between the incidence of COVID-19 pandemic and the human development index in the world (Khazaei et al., 2020). HIV is still widely studied as an infectious disease of concern, Menon-Johansson utilized the Kendall tau test, a non-parametric measure of correlation, assessed that HIV prevalence is significantly associated with poor governance, while in his research, the governance capacity is also be calculated relative to health, education, military and Gross Domestic Product (GDP) (Menon-Johansson, 2005). Rizvi used the method of the learning model to test the economic, environmental indicators and disease prevalence along with COVID-19 pandemic variables, among them he raised a significant correlation between health expenditure and COVID-19 pandemic outcomes, and presumably due to better tracking and reporting of cases rather than a direct negative impact of high health expenditure on mortality rate (Rizvi et al., 2021). However, the data in these articles are estimated by models or data from a certain period of COVID-19 pandemic, but not real data during this epidemic. LPI is also one of world development indicator, is used to evaluate and compare logistics performance levels in different countries and regions. Tian used the method of landscape metrics shown that the higher urbanization, the higher the LPI (Tian et al., 2022), while Yu used the method of GMM model concluded that the smaller urbanization, the fewer infection cases (Yu et al., 2021), these two indicators show conflicting results.

2.4 Relationship between world development indicators and HL

HL, deeply rooted in history since the mid-19th century, emphasizes the cost-effective transportation of aid to address health crises stemming from disasters (Green et al., 2013). Since then, the research delves into various subareas of HL, including definition, performance, management, sustainability, inventory management, and standards (Altay et al., 2024), all aimed at integrating best practices from

logistics and supply chain management for effective disaster response and recovery (Henrique de Moura et al., 2020).

Addressing the impact of epidemics like COVID-19 pandemic requires a comprehensive evaluation of logistics performance to meet humanitarian needs. Holguin-Veras proposed an optimal objective function model combining social costs, logistics and deprivation costs for integrating welfare economic principles into post-disaster HL models to ensure that delivery strategies maximize benefits for the largest number of people (Holguin-Veras et al., 2013). Boostani also aim to minimize the total costs of the humanitarian relief supply chain, maximize social welfare and reduce environmental impacts but used a multi-objective mixed-integer stochastic programming approach. The proposed sustainable humanitarian relief logistics problem is addressed using the Compromise Programming technique and the Lexicographic Optimization Method (Boostani et al., 2021). There are also some scholars targeting developing areas. Babatunde suggested a model worthy of consideration by humanitarian and disaster response stakeholders as well as public health authorities in developing countries (Babatunde et al., 2020).

Recently, The scope of HL objectives is gradually evolving with environmental sustainability and life cycle assessment, such as waste management, power generation, and CO₂ emissions mitigation (Full et al., 2022). Ouni used structural equation modeling summarized indicators relevant to environmental factors: GDP, Foreign Direct Investments (FDI), Renewable Energy Consumption, Green Innovation, Trade Openness (TO) and Transport Carbon dioxide Emissions (Ouni & Ben Abdallah, 2024), which nearly covered all indicators that have association between Green Logistic and environmental degradation. These factors, critical in pandemic acceleration, raise questions about their role in epidemic spread and the environmental impact within a logistic context. While research typically spans from 2007 to 2018 due to data availability limitations during the COVID-19 pandemic (2018-2022). But the research region as an innovation has been explained in great detail, as big as a continent (Io Storto & Evangelista, 2023) or as small as a country (Nayak et al., 2024), classification by high perform group: top 25 ranked LPI countries (Magazzino et al., 2021) is a novel. The results are different in various time periods with all kinds of study areas, but the common of these studies are that the variables are strongly correlated with environmental and logistics performance.

2.5 Research gap

The data in previous research are estimated by models or preceding infectious diseases data or just a certain period of COVID-19 pandemic, instead of real or comprehensive data during this latest pandemic. The epidemic's transmissibility requires cooperation between countries, so an empirical investigation with a global perspective is needed to validate the relationship between epidemics and logistics performance. National policies are closely related to the world development indicators, logistics is a part of this index, and they influence each other, so how to balance the development between them in order to better meet the needs of HL is worth to evolution. Overall, this study aims to verify the statements of some previous literatures with this latest large-scale infectious disease, the findings of this study will comprehensive and reliable demonstrate the importance of logistics performance index and underlying world development indicators in understanding the spread and impact of COVID-19 pandemic across different countries. These insights can help policymakers tailor their strategies to mitigate the effects of the pandemic effectively.

3. Data and Methodology

3.1. Data

This study utilizes cross-sectional data from 155 countries spanning the years 2014 to 2023. the countries' name dataset divisions are detailed in appendix. The COVID-19 cases (CC) and COVID-19 dies (CD) data spanning the years 2020 to 2022, was searched from WHO (World Health Organization, 2024). Industrialization is measured by industry value added as a proportion of GDP, reflecting increased industrial activity and higher energy usage (Sadorsky, 2013). Urbanization (URP) is represented by urban population as a percentage of the total population. Trade openness (TRO), FDI

and Industry (including construction) (LIVA) are all measured as a percentage of GDP value. Population Density (PPD) is calculated by dividing the population by area. Urban population (UP) refers to city inhabitants. The data of LPI and the World Development Indicators, which was released by the World Bank in 2023 (World Bank, 2023). The variables employed to empirically test the hypotheses outlined above are sourced from multiple sources. The impact of the pandemic transcends demographic and national boundaries, affecting individuals of all ages and nationalities with equal force and intensity.

In order to gain a clearer understanding of logistics performance, we use specific logistics performance indicators alongside an overall logistics performance metric. First, Pearson ranked correlation analysis is conducted between the different LPIs and the measures of disaster impact from Covid-19 pandemic and the world development indicators. Nonetheless, it was noted that there was a substantial multicollinearity among the governance indicators (da Silva et al., 2023), so the Variance Inflation Factor test (VIF) and Regression test were used on the governance variables in order to generate factors orthogonal to each other to avoid the effect of multicollinearity. Second, an ordinary least square regression model that strives to portray how different continents' logistics performance influences disasters impact. We used the following regression model:

$$CC = \beta_0 + \beta X + \gamma Z + \varepsilon_1 \quad (1)$$

$$CD = \alpha_0 + \alpha X + \delta Z + \varepsilon_2 \quad (2)$$

Where β_0 and α_0 is the constant term, X is the vector of independent variables (logistic performance) and Z is the vector of control variables (geographic region). And ε is the error term. This regression model also developed for each specific LPI indicator (the six indicators of LPI are marked as tracking and tracing (LPITT), services quality and competence (LPITC), international shipments (LPIIS), customs (LPIC), timeliness (LPIT), and infrastructure (LPIIN). The LPI value ranges from 1 to 5; 1 depicts low logistics performance while 5 represents high logistics performance).

4. Results

VIF is a measure used in regression analysis to detect multicollinearity among predictor variables. As the table 1 shows, VIFs are all around 1, so both LPIs and the world development indicators are no multicollinearity.

Table 1: Result of variance inflation factor test

| Dependent Variable: CC | | | Dependent Variable: CD | |
|------------------------|-----------|---------|------------------------|---------|
| Variables | model 1 | | model 2 | |
| | Tolerance | VIF | Tolerance | VIF |
| FDI | 0.955 | 1.047 | 0.955 | 1.047 |
| URP | 0.575 | 1.74 | 0.575 | 1.74 |
| TRO | 0.733 | 1.365 | 0.733 | 1.365 |
| UP | 0.587 | 1.703 | 0.587 | 1.703 |
| PPD | 0.785 | 1.274 | 0.785 | 1.274 |
| Dependent Variable: CC | | | Dependent Variable: CD | |
| Variables | model 3 | | model 4 | |
| | Tolerance | VIF | Tolerance | VIF |
| LPI | 0.003 | 375.938 | 0.003 | 375.938 |
| LPIC | 0.035 | 28.652 | 0.035 | 28.652 |
| LPIIN | 0.042 | 23.858 | 0.042 | 23.858 |
| LPIIS | 0.065 | 15.299 | 0.065 | 15.299 |
| LPITC | 0.038 | 26.218 | 0.038 | 26.218 |
| LPITT | 0.044 | 22.727 | 0.044 | 22.727 |
| LPIT | 0.065 | 15.4 | 0.065 | 15.4 |

The descriptive statistics and correlation matrix in Table 3 illustrate the distribution and relationships between the variables. Mean value of overall LPI is 2.92, and the logistics performance of different regions can be assessed by comparing their values to this benchmark. The results indicate strong positive correlations between LPI and certain factors like CC and CD, suggesting that countries with better logistics performance experienced more severe epidemic situations. This finding challenges the beliefs of some scholars who argued otherwise (Anser et al., 2021; Pant et al., 2023). Six LPI indicators provide valuable insights into the dynamics of the COVID-19 pandemic. LPIT emerges as the indicator with the highest mean value, while LPIIC remains the lowest, shows that the logistics market most concern about timeliness, but pay less attention on custom. LPIIN exhibits the highest standard deviation, reveals that the level of facilities varies widely around the world. These rankings remained consistent even after the inclusion of 2023 data, aligning with earlier Karaduman's studies (Karaduman et al., 2020). Despite countries who demonstrated strong performance in LPIT and LPIIN, it appears that these timeliness and facilities advantages did not necessarily translate to effective control of the epidemic, particularly in terms of control CC and CD. This contradicts prior findings by Dai (Dai et al., 2021), and emphasizes the need for accessible and equitable supply chain strategies to address the limited COVID-19 pandemic vaccine supply, as highlighted by Shiri (Shiri & Ahmadizar, 2023).

Then the relationship between epidemics and world development indicators was observed. Adjusted R-squared is a measurement of how well the independent variables in a regression model explain the variability in the dependent variable. analyze from table 2, more than 20% CC proportion of the variance in the dependent variable is explained by the independent variables in the model, there is a much larger proportion of CD, more than 25 percent.

Table 2: Regression results.

| Variables | Dependent Variable: CC | | Dependent Variable: CD | |
|------------|-------------------------------------|-----------|-------------------------------------|----------|
| | Model 1 AdjR ² :0.204 | DW= 2.136 | Model 2 AdjR ² :0.257 | DW=2.163 |
| | Coeffi | Sig. | Coeffi | Sig. |
| (Constant) | 775486.491 | 0.355 | 12608.461 | 0.412 |
| FDI | 2.89E ⁻⁰⁹ | 0 | 4.36E ⁻⁰⁷ | 0 |
| URP | -58182.673 | 0.67 | -801.517 | 0.753 |
| TRC | -7596.391 | 0.024 | -183E ⁻⁰² | 0.004 |
| UP | 9378.765 | 0.363 | 287.704 | 0.135 |
| PPD | -117.321 | 0.658 | -1.226 | 0.804 |

Certainly, CD and CC are strongly related, and they show a negative correlation with TRC. It means that the more open a country's economy is to international trade, and the more dependent it is on international trade, the less affected it is by the epidemic. the other side, a high number of infection deaths had a largely negative effect on exports plus imports trade, which is agree with that balancing and reconciling health-related and economic outcomes is a challenging task (Mena et al., 2022). However, FDI show positive correlation with both CC and CD, which means the more epidemic affection have had the more investments made by foreign entities within a country's borders, this intuitively rejects the previous research results of negative correlation (Ho & Gan, 2021). Under 0.05 significant level, CC displays notable positive correlation with UP, means that as the urban population increases, the number of infected persons also tends to increase. The COVID-19 pandemic has once again confirmed the conclusions of previous study (Hamidi et al., 2020). But URP is negative correlation with the cases number, it means the higher the proportion of people living in cities, the lower the number of infections, because URP is also positively correlated with all other variables, it indicates that population distribution in urban city is conducive to epidemic prevention and control, beneficial to resource deployment and government control, but if the population is too dense, it will explode. Similar conclusion with the study of dynamic nonlinear effects of urbanization on wastewater

discharge, this result close related with HL (Liu & Guo, 2023), appropriate density of urban population can effectively alleviate the quality of humanitarian logistics assistance.

The scope of HL objectives is gradually evolving with environmental sustainability, while the dynamic relationship between trade openness, urbanization, industrialization, and environment has been indicated by a wealth of evidence. Although there is limited data available for only one year (2020) on Covid-19 pandemic infection rates and CO₂ emissions, correlation analysis does not show a correlation between them (as shown in Table 4), but from table 3 can realize that the LPIA, URP and TRQ have a significant influence on CO₂ emissions. CC is negative correlation with URP and TRQ, positive correlation with FDI, did not have obvious correlation with LPIA. So, from the aspect of FDI, Covid-19 pandemic infection rate have a positive relationship with CO₂ emissions, especially in developing countries which has been confirmed by Essandoh (Essandoh et al., 2020), while from the aspect of TRQ, Covid-19 pandemic infection rate may have a positive relationship with CO₂ emission, especially in Asian which has been confirmed by Liu (Liu et al., 2022), these two conclusions coincide, underscores the importance of considering external factors, such as the impact of a global pandemic, in analyzing environmental sustainability. Therefore, further analysis is necessary to explore and understand the potential relationship between these variables. The reduction of CO₂ emissions facilitates environmental sustainability which is also the pursue of HL.

Table 3: Descriptive statistics and correlation matrix

| Description | LPI | CC (M) | CD (K) | LPIC | LPIIN | LPIIS | LPITC | LPITT | LPIT |
|--------------------|-------|-----------|-----------|-------|-------|-------|-------|-------|-------|
| Mean | 2.823 | 1.551 | 19.19 | 2.740 | 2.803 | 2.884 | 2.881 | 2.944 | 3.265 |
| Median | 2.790 | 0.177 | 2.053 | 2.604 | 2.600 | 2.802 | 2.741 | 2.850 | 3.2 |
| Standard Deviation | 0.586 | 5.548 | 59.282 | 0.609 | 0.699 | 0.525 | 0.624 | 0.643 | 0.587 |
| Minimum | 1.716 | 0.227 | -3.758 | 1.286 | 1.471 | 1.700 | 1.681 | 1.514 | 1.875 |
| Maximum | 4.300 | 66.049 | 610.371 | 4.208 | 4.600 | 4.235 | 4.400 | 4.400 | 4.796 |

Correlation Matrix

| | | | | | | | | | |
|-------|------|------|-------|------|------|------|------|------|---|
| LPI | 1 | | | | | | | | |
| CC | .263 | 1 | | | | | | | |
| CD | .182 | .728 | 1 | | | | | | |
| LPIC | .851 | .222 | 0.14 | 1 | | | | | |
| LPIIN | .864 | .27 | .179 | .942 | 1 | | | | |
| LPIIS | .931 | .23 | 0.135 | .865 | .881 | 1 | | | |
| LPITC | .978 | .265 | .183 | .930 | .953 | .891 | 1 | | |
| LPITT | .962 | .27 | .208 | .904 | .928 | .905 | .943 | 1 | |
| LPIT | .933 | .23 | .186 | .866 | .888 | .869 | .902 | .903 | 1 |

| | | | | | | | | | |
|-----------------|--------|--------|--------|------|--------|-------|--------|--------|-------|
| TRO | 299 | -115 | -174 | 316 | 306 | 293 | 277 | 267 | 265 |
| UP | 527 | 109 | 129 | 479 | 546 | 510 | 508 | 502 | 513 |
| PPD | 238 | -0.009 | -0.023 | 253 | 245 | 225 | 238 | 220 | 188 |
| FDI | 321 | 628 | 813 | 304 | 339 | 290 | 320 | 315 | 285 |
| URP | -392 | -094 | -095 | -391 | -395 | -393 | -399 | -388 | -415 |
| CO ₂ | 142 | 0.05 | 0.073 | 119 | 128 | 142 | 109 | 145 | 147 |
| GDP | -106 | 0.053 | 0.041 | -094 | -138 | 0.087 | -111 | -101 | -118 |
| LIVA | -0.088 | -0.013 | -0.041 | -127 | -0.062 | 0.035 | -0.067 | -0.065 | 0.068 |

| Continu e | TRO | UP | PPD | FDI (M) | URP | CO ₂ | GDP | LIVA |
|--------------------|---------|---------|----------|------------|---------|-----------------|--------|--------|
| Mean | 89.257 | 60.747 | 251.299 | 11252.090 | 1.907 | 4.232 | 2.658 | 26.861 |
| Median | 72.380 | 62.547 | 79.494 | 11454.743 | 1.839 | 3.050 | 3.158 | 25.223 |
| Standard Deviation | 61.862 | 22.270 | 862.346 | 47680.060 | 1.792 | 5.084 | 5.825 | 10.917 |
| Minimum | 2.699 | 11.776 | 1.854 | 330338.474 | -14.025 | 0.035 | 32.909 | 2.759 |
| Maximum | 425.976 | 100.000 | 7918.951 | 49308.000 | 12.771 | 37.105 | 63.368 | 70.549 |

Continue

| | | | | | | | | |
|-----------------|--------|--------|--------|--------|--------|-------|-------|---|
| TRO | 1 | | | | | | | |
| UP | 0.339 | 1 | | | | | | |
| PPD | 0.507 | 0.202 | 1 | | | | | |
| FDI | 0.001 | 0.142 | 0.201 | 1 | | | | |
| URP | -0.23 | -0.451 | -0.117 | -0.118 | 1 | | | |
| CO ₂ | 0.102 | 0.16 | 0.021 | 0.1 | -0.124 | 1 | | |
| GDP | 0.061 | -0.13 | 0.01 | 0.023 | 0.116 | 0.037 | 1 | |
| LIVA | -0.089 | 0.082 | -0.15 | -0.015 | 0.084 | 0.042 | 0.065 | 1 |

Note: The significance levels in this study are: white color background at $p < 0.1$, light blue significant at $p < 0.05$ and dark blue significant at $p < 0.01$.

Table 4: Relationship between CC; CD and CO₂ by continent

| | AFR O- CO ₂ | AMR O- CO ₂ | EMR O- CO ₂ | EUR O- CO ₂ | SEAR O-CO ₂ | WPR O- CO ₂ |
|-----------------|------------------------------|------------------------------|------------------------------|------------------------------|---------------------------|------------------------------|
| AFR O- CC | 0.00 9 | AMR O-CC 0.238 | EMR O-CC 0.032 | EUR O- CC 0.133 | SEAR O-CC -0.283 | WPR O-CC 0.311 |
| AFR O- CD | 0.00 9 | AMR O-CD 0.283 | EMR O-CD 0.038 | EUR O- CD 0.113 | SEAR O-CD -0.304 | WPR O-CD 0.144 |

Further investigate these relationships by dividing the world into five continents according to the classification of the World Health Organization. Different continents have obvious different epidemic prevention and control policy, the development backgrounds also have their own characteristics. According to the calculation, the global infection rate from 2020 to 2022 was calculated at 1.63%, with a subsequent 1.2% death rate post-infection. However, in 2023, considered the peak year for epidemic containment, the infection rate dropped to 0.57% while the death rate rose to 1.55%. Table 5 illustrate that Americas (AMRO) had a slightly higher CC than Europe (EURO), ranking first and second, respectively, but with a significantly higher Fatality Rate (FR). The COVID-19 pandemic outbreak, originating in Wuhan, China, in late 2019, spread rapidly worldwide. Initially, outbreaks tend to impact the originating country more severely due to factors like delayed recognition and a lack of preparedness (Wilder-Smith & Osman, 2020). Notably, South-East Asia (SEARO) experienced more severe consequences compared to Western Pacific (WPRO), potentially influenced by factors such as resident adherence to Preventive Measures, Government policy (Ditekemena et al., 2021), and Hofstede's Cultural Dimensions (Chang & Wu, 2023). Efforts to minimize Fatality Rates are crucially tied to national initiatives (He et al., 2020). Safeguarding the right to life and health is a fundamental responsibility (Ram-Tiktin, 2012), every state should do its utmost to protect the rights and interests of not only their citizen but more people around the world which are also the pursuit of humanitarianism logistic. The disruption caused by the COVID-19 pandemic outbreak in 2020 affected the release of the Logistics Performance Index (LPI) report. While the LPI resumed in 2023, varying timelines for lifting epidemic restrictions globally led to a surge in cases and deaths (Hansun et al., 2023). The results showed that the correlation was positive, indicating that the better the logistics performance, the more infected people, so the development of logistics did not meet the humanitarian requirements. The drop on infection rates in 2023 confirmed the vaccine's effectiveness, while infection rates in WPRO also verified the importance of national policy and control.

Table 5: Comparison of data by continent (2020-2022)

| | Mean 20-22 TTCC (M) | Mean 20-22 TTCD (K) | 20- 22 FR % | TP (M) | CC % | 2023 TTCC (M) | 2023 TTCD (K) | 23 CC % | 23 CASE % | 23 LP |
|-----------|------------------------------|------------------------------|----------------------|--------------|---------|---------------------|---------------------|---------------|-----------------|----------|
| AFRO | 22.040 | 379.920 | 1.7 2 | 7515.00 0 | 0.29 | 10.33 7 | 197.380 | 1.91 | 0.14 | 2.6 3 |
| AMRO | 217.87 2 | 3810.46 0 | 1.7 5 | 7267.28 3 | 3.00 | 73.95 1 | 1571.76 4 | 2.13 | 1.02 | 2.9 6 |
| EMRO | 27.276 | 457.981 | 1.6 8 | 7523.56 5 | 0.36 | 12.11 8 | 193.557 | 1.60 | 0.16 | 2.8 8 |
| EURO | 239.34 5 | 2219.68 8 | 0.9 3 | 7322.25 1 | 3.27 | 60.94 5 | 953.373 | 1.56 | 0.63 | 3.3 1 |
| SEAR O | 72.582 | 984.988 | 1.3 6 | 6513.71 8 | 1.11 | 33.55 2 | 542.715 | 1.62 | 0.52 | 2.9 0 |
| WPRO | 128.75 2 | 308.845 | 0.2 4 | 7316.45 4 | 1.76 | 54.55 3 | 255.281 | 0.47 | 0.75 | 3.0 6 |

Note: Africa (AFRO), Americas (AMRO), Eastern Mediterranean (EMRO), Europe (EURO), South-East Asia (SEARO), and Western Pacific (WPRO), the regional divisions outlined by the World Health Organization.

5. policy implications

Outbreaks have occurred frequently in recent decade (Craun et al., 2010; Schirone & Visciano, 2021), and some experts predict the increasing frequency of international infectious diseases, such as COVID-19 pandemic, and their devastating impact on society (World Health Organization, 2022). To address these challenges effectively, proactive measures and coordinated efforts are crucial. This study highlights key recommendations for policymakers, practitioners, and stakeholders to better prepare for and respond to future epidemics.

The nature of demand in HL is very uncertain because disaster time, location, and intensity are not known until after a disaster occurs (Nikbakhsh & Farahani, 2011). For policymakers, emphasis should be placed on balancing the quality of healthcare systems and speed of economic growth in recipient countries through support from organizations like the international monetary fund (IMF), the Organization for Economic Co-operation and Development (OECD), the European Union, the World Bank and other institutions (Welfens, 2020). When they try to support economic growth through specific programs for member countries or partner countries, should pay more attention to the quality of the health system of the recipient countries. When the epidemic breaks out, the spread of the epidemic in the underdeveloped regions is slow, but when they have more FDI, the epidemic is spreading faster, then will affect the fairness of more people in the world, which is not the right way to equality. Each region has its own political culture and historical background, it is essential to benchmark scenarios using actual COVID-19 pandemic data to establish a model to propose the FDI quotas of countries.

Urbanization and population density should be carefully managed to control epidemic spread, with a focus on optimizing talent distribution and fostering urban and rural integrated development. Policy initiatives, such as tax incentives, entrepreneurship support, and improved public services, can contribute to creating a resilient livable environment capable of addressing future crises. An appropriate degree of deurbanization will also facilitate logistics to serve the unemployed, low-income vulnerable and high-power groups fairly and equally.

Laws and regulations should be established for medical systems that manage doctor-patient transport, providing assistance to vulnerable individuals in coping with the impacts of the pandemic by delivering resources such as food and medical care. Should include tracking the transport of vulnerable individuals and ensuring that food is safely processed and delivered (Rizou et al., 2020). Create customized pandemic logistical and supply chain frameworks need collaboration among epidemiologists, transport planners and law-maker, which can enhance the government's legitimacy of running multi-echelon, multi-phase, multi-vehicle based models during emergencies (Suthar et al., 2021). In addition to regulatory measures, policymakers should reduce government corruption, implement awareness campaigns, economic support schemes, and health assistance programs to build credibility, interpersonal trust and strengthen pandemic preparedness (Fakir & Bharati, 2021). Early initiated short-term government-imposed social distancing can buy time for healthcare systems to prepare for an increasing COVID-19 pandemic burden (Teshya et al., 2020). Investments in intelligent logistics systems and cold chain infrastructure are essential for facilitating vaccine distribution and controlling disease transmission (Fahmi et al., 2022). However, foreign investment increases the death toll from the pandemic, while domestic trade reduces the death rate, it is not only for political reasons, but also for humanitarian reasons, to consider countries' independent development.

For practitioners in the logistics industry, the impact of epidemics on global supply chains necessitates preparedness for disruptions and challenges. Because FDI is related to CC and CD, some countries with high government effectiveness will definitely control the logistics business related to import and export trade in the future epidemic situation (Liang et al., 2020). However, the impact on profitability varies depending on the specific segment of the logistics industry and how well companies have adapted to the changing landscape. Like air and shipping prices have increased significantly during the pandemic (Isaacson & Rubinton, 2023), but due to trade restrictions, a labor shortage, or the closure of important distribution hubs like ports, airports, or distribution centers all universally had negatively impact on domestic logistic company's ability to distribute goods and services (Notteboom et al., 2021). So amplify global supply chain company need to efforts in digital transformation and build autonomous, networked ecosystems out of their supply chains, ensure availability during an outbreak (Ozkanlısoy, 2021). The collapse of many international supply chain companies also indicates that Companies should prioritize digital transformation, build resilient supply chain ecosystems, and diversify sourcing strategies to mitigate risks. Attention should be given to both forward and reverse logistics, including proper waste management and sustainable practices to minimize environmental impact (Kargar et al., 2020). Logistics companies should also be aware of the powerful forces from ACEs, PIEs and CANs, laying out the network in advance can better win the market in urgent situations. Proactively seek cooperation with government agencies and local effort that exists for humanitarianism purpose, even can thinking about organize their own end distribution personnel operations intrinsic to the local community in advance.

Moreover, stakeholders at all levels, including individuals and organizations, should actively participate in disaster preparedness and response efforts. Encouraging domestic production, reducing waste, and promoting sustainable practices can boost resilience and contribute to long-term human development (Butzbach et al., 2020). Collaboration with public welfare organizations and engagement in community-based initiatives are essential for supporting vulnerable populations and building a more resilient society. By adopting a holistic approach that integrates policy interventions, industry best practices, and community engagement, stakeholders can collectively enhance epidemic preparedness, mitigate risks, and safeguard public health in the face of future challenges.

6. Conclusion

Despite huge scientific and medical advances, the potential for diseases to spread is actually increasing, and the risk of outbreaks escalating into epidemics or pandemics (Haileamlak, 2022), the rise of HL research coincides with the frequent outbreak of epidemics. In conclusion, this empirical study delves into the intricate relationship between COVID-19 pandemic and logistics performance,

shedding light on the dynamics of epidemic spread and the critical role logistics plays in mitigating such crises. The findings highlight that while enhanced logistics performance may exacerbate the severity of an epidemic, it also enables a relatively faster reduction in infection rates. Moreover, foreign investment increases the death toll from the pandemic, while domestic trade reduces the death rate, the appropriate urban population density will help logistic to control the epidemic spread. The significance of national policies, vaccine efficacy, and geographic factors in shaping the trajectory of COVID-19 pandemic outbreaks is underscored.

Moving forward, this study is based on the theory of HL, underscores the urgency of accelerating the development of smart logistics systems in high-infection regions with robust economies. Emphasizing the importance of independent study and development, encouraging international knowledge cooperation, and addressing urbanization challenges are key strategies for navigating future pandemics effectively. Additionally, there is a pressing need for empirical study in the field of HL to explore the interplay between CO₂ emissions, waste management, and energy systems during epidemics.

As we navigate the complexities of epidemic response and recovery, policymakers, practitioners, and stakeholders are urged to heed the insights gleaned from this study. By fostering a global village mindset and prioritizing collaborative efforts, we can pave the way for a healthier, more resilient future for all. Looking ahead, a proactive approach informed by past experiences and governance indicators will be crucial in preempting and managing potential future pandemics effectively.

7. Appendix

Table 6: Dataset divisions.

| Western Pacific | | Eastern Mediterranean | | Africa | | | |
|-------------------|------|-----------------------|------|--------------------------|------|---------------|------|
| Country | Code | Country | Code | Country | Code | Country | Code |
| Australia | AUS | Afghanistan | AFG | Algeria | DZA | Guinea-Bissau | GNB |
| Brunei Darussalam | BRN | Bahrain | BHR | Angola | AGO | Kenya | KEN |
| Cambodia | KHM | Djibouti | DJI | Benin | BEN | Lesotho | LSO |
| China | CHN | Egypt, Arab Rep. | EGY | Burkina Faso | BFA | Liberia | LBR |
| Fiji | FJI | Iran, Islamic Rep. | IRN | Burundi | BDI | Madagascar | MAD |
| Japan | JPN | Iraq | IRQ | Cameroon | CMR | Malawi | MWI |
| Korea, Rep. | KOR | Jordan | JOR | Central African Republic | CAF | Mali | MLI |
| Lao PDR | LAO | Kuwait | KWT | Chad | TCD | Mauritania | MRT |

| | | | | | | | |
|---------------------|-----|----------------|-----|-------------------|-----|--------------|-----|
| Malaysia | M Y | | | | C O | | |
| | S | Lebanon | LBN | Comoros | M | Mauritius | MUS |
| Mongolia | M N | | | Congo, Dem. | | | |
| | G | Lithuania | LTU | Rep. | ZAR | Niger | NER |
| New Zealand | NZL | Morocco | M A | | C O | | |
| | | | R | Congo, Rep. | G | Nigeria | NGA |
| Papua New Guinea | P N | | O M | | H R | São Tomé and | |
| | G | Oman | N | Croatia | V | Príncipe | STP |
| Philippines | PHL | Pakistan | PAK | Equatorial Guinea | G N | | |
| | | | | | Q | Senegal | SEN |
| Slovak Republic | SVK | Saudi Arabia | SAU | Eritrea | ERI | Sierra Leone | SLE |
| Trinidad and Tobago | TTO | Sudan | S D | | G A | | |
| | | | N | Gabon | B | Singapore | SGP |
| Uganda | U G | Turkmenista | T K | | G M | | |
| | A | n | M | Gambia, The | B | South Africa | ZAF |
| Vietnam | V N | United Kingdom | G B | | G H | | |
| | M | | R | Ghana | A | Ukraine | UKR |
| South-East Asia | | Yemen, Rep. | Y E | | | | |
| | | | M | Guinea | GIN | Zambia | ZMB |
| | | | | | | Zimbabwe | ZWE |

| Americas | | | | Europe | | | |
|------------------------|-----|---------------|-----|-----------------|-----|-------------|-----|
| Country | Co | de | | Country | Co | de | |
| Argentina | A R | | | Albania | ALB | | |
| | G | Peru | PER | Kyrgyz Republic | KGZ | | |
| Bahamas, The | B H | | | Armenia | ARM | Latvia | LVA |
| | S | Qatar | QAT | Austria | AUT | Luxembourg | LUX |
| Bolivia | BOL | Slovenia | SVN | Belarus | BLR | Malta | MLT |
| Bosnia and Herzegovina | BIH | Tunisia | TUN | Belgium | BEL | Moldova | MDA |
| Brazil | B R | | | Bulgaria | BGR | Montenegro | MNE |
| | A | Turkey | TUR | | | | |
| Canada | C A | United States | USA | Côte d'Ivoire | CIV | Netherlands | NLD |
| | N | | | | | | |
| Chile | CHL | Uruguay | URY | Czech Republic | CZE | Norway | NOR |
| Colombia | C O | Venezuela, RB | VEN | | | | |
| | L | | | | | | |

| | | | | | | | |
|-------------------------|----------|--------------------|----------|---------|-----|-----------------------------|-----|
| Costa Rica | CRI | | | Denmark | DNK | Poland | POL |
| Cyprus | C Y P | South-East Asia | | Estonia | EST | Portugal | PRT |
| | | | Co de | Finland | FIN | R u s s i a n Federation | RUS |
| Dominican Republic | D O M | Country | | | | | |
| Ecuador | E C U | Bangladesh | B G D | France | FRA | Rwanda | RWA |
| | | Bhutan | BTN | Georgia | GEO | Serbia | SRB |
| El Salvador | S L V | | | Germany | DEU | Solomon Islands | SLB |
| | | India | IND | | | Greece | GRC |
| Guatemala | G T M | Indonesia | IDN | Hungary | HUN | Spain | ESP |
| | | | | | | Iceland | ISL |
| Guyana | G U Y | Maldives | M D V | Ireland | IRL | Switzerland | CHE |
| | | | | | | Israel | ISR |
| Haiti | HTI | Myanmar | M M R | Italy | ITA | United Arab Emirates | ARE |
| Hong Kong SAR, China | H K G | Nepal | NPL | | | Kazakhstan | KAZ |
| Jamaica | JAM | Sri Lanka | LKA | | | | |
| Mexico | M E X | Thailand | THA | | | | |
| | | | | | | | |
| Panama | P A N | Togo | T G O | | | | |
| Paraguay | P R Y | | | | | | |

Source: World Health Organization

Abbreviated Glossary

World Health Organization (WHO)

Agency Centric Efforts (ACEs)

Partially Integrated Efforts (PIEs)

Collaborative Aid Networks (CANs)

EU or European Economic Area (EU/EEA)

Logistics performance Index (LPI)

Gross Domestic Product (GDP)

Foreign Direct Investments (FDI)

Renewable Energy Consumption (REC)

Trade Openness (TO)

Humanitarian Logistics (HL)

Humanitarian Supply Chains Management (SHSCM)
COVID-19 pandemic cases (CC)
COVID-19 pandemic dies (CD)
Logistic Tracking and Tracing (LPITT)
Logistic Services Quality and Competence (LPITC)
Logistic International Shipments (LPIIS)
Logistic Customs (LPIC)
Logistic Timeliness (LPIT)
Logistic Infrastructure (LPIIN)
Urbanization (URP)
Trade Openness (TRO)
Industry (LIVA)
Population Density (PPD)
Urban population (UP)
Africa (AFRO)
Americas (AMRO)
Eastern Mediterranean (EMRO)
Europe (EURO)
South-East Asia (SEARO)
Western Pacific (WPRO)
The International Monetary Fund (IMF)
The Organisation for Economic Co-operation and Development (OECD)

8. References

- Altay, N., Heaslip, G., Kovács, G., Spens, K., Tatham, P., & Vaillancourt, A. (2024). Innovation in humanitarian logistics and supply chain management: A systematic review. *Annals of Operations Research*, 335(3), 965–987. <https://doi.org/10.1007/s10479-023-05208-6>
- Anser, M. K., Khan, M. A., Nassani, A. A., Abro, M. M. Q., Zaman, K., & Kabbani, A. (2021). Does COVID-19 pandemic disrupt sustainable supply chain process? Covering some new global facts. *Environmental Science and Pollution Research*, 28(42), 59792–59804. <https://doi.org/10.1007/s11356-021-14817-2>
- Babatunde, S., Olorunjoba, R., & Agho, K. (2020). Healthcare commodities for emergencies in Africa: Review of logistics models, suggested model and research agenda. *Journal of Humanitarian Logistics and Supply Chain Management*, 10(3), 371–390. <https://doi.org/10.1108/JHLSCM-09-2019-0054>
- Bachofen, C. (2018). Selected Viruses Detected on and in our Food. *Current Clinical Microbiology Reports*, 5(2), 143–153. <https://doi.org/10.1007/s40588-018-0087-9>
- Baker, R. E., Mahmud, A. S., Miller, I. F., Rajeev, M., Rasambainarivo, F., Rice, B. L., Takahashi, S., Tatem, A. J., Wagner, C. E., & Wang, L.-F. (2022). Infectious disease in an era of global change. *Nature Reviews Microbiology*, 20(4), 193–206.
- Boostani, A., Jokai, F., & Bozorgi-Amiri, A. (2021). Designing a sustainable humanitarian relief logistics model in pre- and postdisaster management. *International Journal of Sustainable Transportation*, 15(5), 604–620. <https://doi.org/10.1080/15568318.2020.1773975>
- Butzbach, O., Fuller, D. B., & Schryder, G. (2020). Manufacturing discontent: National institutions, multinational firm strategies, and anti-globalization backlash in advanced economies. *Global Strategy Journal*, 10(1), 67–93. <https://doi.org/10.1002/gsj.1369>
- Chang, L.-H., & Yiu, S. (2023). The Correlation between Hofstede's Cultural Dimensions and COVID-19 Data in the Early Stage of the COVID-19 Pandemic Period. *Healthcare*, 11(16), 2258. <https://doi.org/10.3390/healthcare11162258>
- Craun, G. F., Brunkard, J. M., Yoder, J. S., Roberts, V. A., Carpenter, J., Wade, T., Calderon, R. L., Roberts, J. M., Beach, M. J., & Roy, S. L. (2010). Causes of Outbreaks Associated with Drinking Water in the United States from 1971 to 2006. *Clinical Microbiology Reviews*, 23(3), 507–528. <https://doi.org/10.1128/CMR.00077-09>
- da Silva, R. E., Novaes, M. R. C. G., de Oliveira, C., & Guilhem, D. B. (2023). National governance and excess mortality due to COVID-19 in 213 countries: A retrospective analysis and perspectives on future pandemics. *Globalization and Health*, 19(1), 80. <https://doi.org/10.1186/s12992-023-00952-1>
- Dai, D., Wu, X., & Si, F. (2021). Complexity analysis of cold chain transportation in a vaccine supply chain considering activity inspection and time-delay. *Advances in Difference Equations*, 2021(1), 39. <https://doi.org/10.1186/s13662-020-03173-z>
- Deal, A., Halliday, R., Crawshaw, A. F., Hayward, S. E., Burnard, A., Rustage, K., Carter, J., Mehrotra, A., Knights, F., Campos-Matos, I., Majeed, A., Friedland, J. S., Edelstein, M., Mounier-Jack, S., & Hargreaves, S. (2021). Migration and outbreaks of vaccine-preventable disease in Europe: A systematic review. *The Lancet Infectious Diseases*, 21(12), e387–e398. [https://doi.org/10.1016/S1473-3099\(21\)00193-6](https://doi.org/10.1016/S1473-3099(21)00193-6)
- Ditekemena, J. D., Nkamba, D. M., Muhindo, H. M., Siewe, J. N. F., Luhata, C., Bergh, R. V. den, Kitoto, A. T., Damme, W. V., Muyemba, J. J., & Colebunders, R. (2021). Factors associated with adherence to COVID-19 prevention measures in the Democratic Republic of the Congo (DRC): Results of an online survey. *BMJ Open*, 11(1), e043356. <https://doi.org/10.1136/bmjopen-2020-043356>
- Duroseau, B., Kipshidze, N., & Limaye, R. J. (2023). The impact of delayed access to COVID-19 vaccines in low- and lower-middle-income countries. *Frontiers in Public Health*, 10, 1087138. <https://doi.org/10.3389/fpubh.2022.1087138>
- Edalat, F., Tabatabaie, F. H., Moattari, A., Letafati, A., Sarvari, J., & Hosseini, S. Y. (2024). Delving into revolutionary SARS-CoV-2 vaccine approaches: Molecular and virological examinations; principles of SARS-CoV-2 vaccine platform. *Vaccines (English Edition)*, 25(1), 109–127. <https://doi.org/10.1016/j.vaccine.2024.02.013>
- Essandoh, O. K., Islam, M., & Kakinaka, M. (2020). Linking international trade and foreign direct investment to CO₂ emissions: Any differences between developed and developing countries? *Science of The Total Environment*, 712, 136437.

- <https://doi.org/10.1016/j.scitotenv.2019.136437>
- Fahmi, M. L., Ismail, I. A.-N., Refi, D. M., Almeman, A., Yaakob, N. C., Saman, K. M., Mansor, N. F., Noordin, N., & Babar, Z.-U.-D. (2022a). Management of COVID-19 vaccines cold chain logistics: A scoping review. *Journal of Pharmaceutical Policy and Practice*, 15(1), 16. <https://doi.org/10.1186/s40545-022-00411-5>
- Fahmi, M. L., Ismail, I. A.-N., Refi, D. M., Almeman, A., Yaakob, N. C., Saman, K. M., Mansor, N. F., Noordin, N., & Babar, Z.-U.-D. (2022b). Management of COVID-19 vaccines cold chain logistics: A scoping review. *Journal of Pharmaceutical Policy and Practice*, 15(1), 16. <https://doi.org/10.1186/s40545-022-00411-5>
- Fakir, A. M. S., & Bherati, T. (2021). Pandemic catch-22: The role of mobility restrictions and institutional inequalities in halting the spread of COVID-19. *PLOS ONE*, 16(6), e0253348. <https://doi.org/10.1371/journal.pone.0253348>
- Fang, H., Wang, L., & Yang, Y. (2020). Human mobility restrictions and the spread of the Novel Coronavirus (2019-nCoV) in China. *Journal of Public Economics*, 191, 104272. <https://doi.org/10.1016/j.jpubeco.2020.104272>
- Fuli, G., Foropon, C., & Xin, M. (2022). Reducing carbon emissions in humanitarian supply chain: The role of decision making and coordination. *Annals of Operations Research*, 319(1), 355–377. <https://doi.org/10.1007/s10479-020-03671-z>
- Green, J. L., de Weck, O. L., & Suarez, P. (2013). Evaluating the economic sustainability of sanitation logistics in Senegal. *Journal of Humanitarian Logistics and Supply Chain Management*, 3(1), 7–21.
- Haileamlak, A. (2022). Pandemics Will be More Frequent. *Ethiopian Journal of Health Sciences*, 32(2), 228. <https://doi.org/10.4314/ejhs.v32i2.1>
- Hamidi, S., Sabouri, S., & Ewing, R. (2020). Does Density Aggravate the COVID-19 Pandemic?: Early Findings and Lessons for Planners. *Journal of the American Planning Association*, 86(4), 495–509. <https://doi.org/10.1080/01944363.2020.1777891>
- Hansun, S., Charles, V., & Gherman, T. (2023). The role of the mass vaccination programme in combating the COVID-19 pandemic: An LSTM-based analysis of COVID-19 confirmed cases. *Heliyon*, 9(3), e14397. <https://doi.org/10.1016/j.heliyon.2023.e14397>
- He, A. J., Shi, Y., & Liu, H. (2020). Crisis governance, Chinese style: Distinctive features of China's response to the Covid-19 pandemic. *Policy Design and Practice*, 3(3), 242–258. <https://doi.org/10.1080/25741292.2020.1799911>
- Henrique de Moura, E., Bruno Rocha e Cruz, T., & De Genaro Chirolli, D. M. (2020). A framework proposal to integrate humanitarian logistics practices, disaster management and disaster mutual assistance: A Brazilian case. *Safety Science*, 132, 104965. <https://doi.org/10.1016/j.ssd.2020.104965>
- Ho, L. T., & Gan, C. (2021). Foreign Direct Investment and World Pandemic Uncertainty Index: Do Health Pandemics Matter? *Journal of Risk and Financial Management*, 14(3), Article 3. <https://doi.org/10.3390/jrfm14030107>
- Hohenstein, N.-O. (2022). Supply chain risk management in the COVID-19 pandemic: Strategies and empirical lessons for improving global logistics service providers' performance. *The International Journal of Logistics Management*, 33(4), 1336–1365. <https://doi.org/10.1108/IJLM-02-2021-0109>
- Holgún-Veras, J., Pérez, N., Jaller, M., Van Wassenhove, L. N., & Aros-Vera, F. (2013). On the appropriate objective function for post-disaster humanitarian logistics models. *Journal of Operations Management*, 31(5), 262–280. <https://doi.org/10.1016/j.jom.2013.06.002>
- Hunter, P. R., Colón-González, F. J., Brainard, J., Majuru, B., Pedrazzoli, D., Abubakar, I., Dinsa, G., Suhroke, M., Stuckler, D., Lim, T.-A., & Semenza, J. C. (2020). Can economic indicators predict infectious disease spread? A cross-country panel analysis of 13 European countries. *Scandinavian Journal of Public Health*, 48(4), 351–361. <https://doi.org/10.1177/1403494819852830>
- Isaacson, M., & Rubinton, H. (2023). *Shipping Prices and Import Price Inflation* (SSRN Scholarly Paper 4352338).
- Karaduman, H. A., Karaman-Akgül, A., Çağlar, M., & Akbaş, H. E. (2020). The relationship between logistics performance and carbon emissions: An empirical investigation on Balkan countries. *International Journal of Climate Change Strategies and Management*, 12(4), 449–461. <https://doi.org/10.1108/IJCCSM-05-2020-0041>
- Kargar, S., Pourmehdi, M., & Paydar, M. M. (2020a). Reverse logistics network design for medical waste management in the epidemic outbreak of the novel coronavirus (COVID-19). *Science of The Total Environment*, 746, 141183. <https://doi.org/10.1016/j.scitotenv.2020.141183>

- Kargar, S., Pourmehdi, M., & Paydar, M. M. (2020b). Reverse logistics network design for medical waste management in the epidemic outbreak of the novel coronavirus (COVID-19). *Science of the Total Environment*, 746, 141183.
- Karuppiah, K., Sankaranarayanan, B., Ali, S. M., & Paul, S. K. (2021). Key Challenges to Sustainable Humanitarian Supply Chains: Lessons from the COVID-19 Pandemic. *Sustainability*, 13(11), 1–20.
- Kembro, J., Kunz, N., Frennsson, L., & Vega, D. (2024). Revisiting the definition of humanitarian logistics. *Journal of Business Logistics*, 45(2), e12376. <https://doi.org/10.1111/jbl.12376>
- Khazaei, Z., Goodarzi, E., Naemi, H., Hasangour-Dehkordi, A., & Naghibzadeh-Tahami, A. (2020). COVID-19 pandemic in the world and its relation to human development index: A global study. *Arch Clin Infect Dis*. <http://eprints.iums.ac.ir/2531/>
- Kuznetsova, L. (2020). Covid-19: The world community expects the World Health Organization to play a stronger leadership and coordination role in pandemics control. *Frontiers in Public Health*, 8, 559214.
- Lendacki, F. R., Li, L., Forrest, G. N., Jordan, L., Zelinski, C., Black, S. R., Ison, M. G., & Seo, J. Y. (2024). Breakthrough SARS-CoV-2 infections among recipients of tixagevimab-cilgavimab prophylaxis: A citywide real-world effectiveness study. *Transplant Infectious Disease: An Official Journal of the Transplantation Society*, 26(1), e14194. <https://doi.org/10.1111/tid.14194>
- Liang, L.-L., Tseng, C.-H., Ho, H. J., & Wu, C.-Y. (2020). Covid-19 mortality is negatively associated with test number and government effectiveness. *Scientific Reports*, 10(1), 12567.
- Liu, X., & Guo, W. (2023). Dynamic nonlinear effects of urbanization on wastewater discharge based on inertial characteristics of wastewater discharge. *Science of The Total Environment*, 904, 166514. <https://doi.org/10.1016/j.scitotenv.2023.166514>
- Liu, Z., Pang, P., Fang, W., Ali, S., & Anser, M. K. (2022). Dynamic common correlated effects of pandemic uncertainty on environmental quality: Fresh insights from East-Asia and Pacific countries. *Air Quality, Atmosphere & Health*, 15(8), 1395–1411. <https://doi.org/10.1007/s11869-022-01164-5>
- lo Storto, C., & Evangelista, P. (2023). Infrastructure efficiency, logistics quality and environmental impact of land logistics systems in the EU: A DEA-based dynamic mapping. *Research in Transportation Business & Management*, 46, 100814. <https://doi.org/10.1016/j.rtbm.2022.100814>
- Magazzino, C., Aloia, A. A., & Schneider, N. (2021). The trilemma of innovation, logistics performance, and environmental quality in 25 topmost logistics countries: A quantile regression evidence. *Journal of Cleaner Production*, 322, 129050. <https://doi.org/10.1016/j.jclepro.2021.129050>
- Melton, J. (2022, December 26). *Global parcel volume to grow at 8.5% CAGR through 2027*. <https://www.digitalcommerce360.com/2022/09/26/global-parcel-volume-to-grow-at-8-5-cagr-through-2027/>
- Mena, C., Karatzas, A., & Hansen, C. (2022). International trade resilience and the Covid-19 pandemic. *Journal of Business Research*, 138, 77–91. <https://doi.org/10.1016/j.jbusres.2021.08.064>
- Menon-Johansson, A. S. (2005). Good governance and good health: The role of societal structures in the human immunodeficiency virus pandemic. *BMC International Health and Human Rights*, 5(1), 4. <https://doi.org/10.1186/1472-698X-5-4>
- Mostafayi Darmian, S., & Farughi, H. (2022). An optimization-based approach for managing downstream logistic operations: A real application in pandemic outbreak conditions. *Computers & Industrial Engineering*, 171, 108495. <https://doi.org/10.1016/j.cie.2022.108495>
- Nayak, N., Pant, P., Sarmah, S. P., & Tulshan, R. (2024). Development of in-country logistics performance index for emerging economies: A case of Indian states. *International Journal of Productivity and Performance Management*, ahead-of-print(ahead-of-print). <https://doi.org/10.1108/IJPPM-03-2023-0122>
- Nikbakhtsh, E., & Farahani, R. Z. (2011). Humanitarian logistics planning in disaster relief operations. *Logistics Operations and Management: Concepts and Models*, 29f. [https://books.google.com/books?hl=zh-CN&lr=&id=5iJq-FXb41kC&oi=ind&pg=PA291&dq=Humanitarian+logistics+planning+in+disaster+relief+operations.+In+Elsevier++eBooks+\(pp.+291%E2%80%93332\).&ots=tZ9D5yGfb&sig=0rKcsxtmA8QFzSbhakZdwPFo2ag](https://books.google.com/books?hl=zh-CN&lr=&id=5iJq-FXb41kC&oi=ind&pg=PA291&dq=Humanitarian+logistics+planning+in+disaster+relief+operations.+In+Elsevier++eBooks+(pp.+291%E2%80%93332).&ots=tZ9D5yGfb&sig=0rKcsxtmA8QFzSbhakZdwPFo2ag)
- Notteboom, T., Pallis, T., & Rodrigue, J.-P. (2021). Disruptions and resilience in global container shipping and ports: The COVID-19 pandemic versus the 2008–2009 financial crisis. *Maritime Economics & Logistics*, 23(2), 179–210. <https://doi.org/10.1057/s41278-020-00180-5>
- Ouni, M., & Ben Abdallah, K. (2024). Environmental sustainability and green logistics: Evidence from

- BRICS and Gulf countries by cross-sectionally augmented autoregressive distributed lag (CS-ARDL) approach. *Sustainable Development*, sd.2856. <https://doi.org/10.1002/sd.2856>
- Ozkanlısoy, O. (2021). THE COVID-19 OUTBREAK'S EFFECTS AND NEW INCLINATIONS IN TERMS OF LOGISTICS AND SUPPLY CHAIN ACTIVITIES: A CONCEPTUAL FRAMEWORK. *Journal of Management Marketing and Logistics*, 8(2), Article 2. <https://doi.org/10.17261/Pressacademia.2021.1408>
- Pant, D. P., Acharya, B., & Kattel, M. R. (2023). Association of government effectiveness, logistics performance, IT systems and income with COVID-19 mortality. *Heliyon*, 9(4). [https://www.cell.com/heliyon/pdf/S2405-8440\(23\)02421-0.pdf](https://www.cell.com/heliyon/pdf/S2405-8440(23)02421-0.pdf)
- Priya, S. P., Sunil, P. M., Varma, S., Brigi, C., Isnadi, M. F. A. R., Jayalal, J. A., Shadamarshan, R. A., Kumar, S. S., Kumari, N. V., & Kumar, R. P. R. (2022). Direct, indirect, post-infection damages induced by coronavirus in the human body: An overview. *VirusDisease*, 33(4), 429–444. <https://doi.org/10.1007/s13337-022-00793-9>
- Priyadarshini, S. L., Suresh, M., & Huisingh, D. (2020). What can we learn from previous pandemics to reduce the frequency of emerging infectious diseases like COVID-19? *Global Transitions*, 2, 202–220.
- Ram-Tiktin, E. (2012). The Right to Health Care as a Right to Basic Human Functional Capabilities. *Ethical Theory and Moral Practice*, 15(3), 337–351. <https://doi.org/10.1007/s10677-011-9322-7>
- Rizou, M., Galanakis, I. M., Aldawoud, T. M. S., & Galanakis, C. M. (2020). Safety of foods, food supply chain and environment within the COVID-19 pandemic. *Trends in Food Science & Technology*, 102, 293–299. <https://doi.org/10.1016/j.tfs.2020.06.008>
- Rizvi, S. A., Umair, M., & Cheema, M. A. (2021). Clustering of countries for COVID-19 cases based on disease prevalence, health systems and environmental indicators. *Chaos, Solitons & Fractals*, 151, 111240. <https://doi.org/10.1016/j.chaos.2021.111240>
- Schirone, M., & Visciano, P. (2021). Trends of major foodborne outbreaks in the European Union during the years 2015–2019. *Hygiene*, 1(3), 106–119.
- Shiri, M., & Ahmadizar, F. (2023). An equitable and accessible vaccine supply chain network in the epidemic outbreak of COVID-19 under uncertainty. *Journal of Ambient Intelligence and Humanized Computing*, 14(11), 14695–14719. <https://doi.org/10.1007/s12652-022-03865-2>
- Sohrabi, C., Alsafi, Z., O'Neill, N., Khan, M., Kerwan, A., Al-Jabir, A., Losifidis, C., & Agha, R. (2020). World Health Organization declares global emergency: A review of the 2019 novel coronavirus (COVID-19). *International Journal of Surgery*, 78, 71–76.
- Strail-Bourgeois, S., Tonzeil, J. L., Kretzschmar, M., & Ratard, R. (2023). Infectious Disease Epidemiology. In W. Ahrens & I. Piguet (Eds.), *Handbook of Epidemiology* (pp. 1–79). Springer New York. https://doi.org/10.1007/978-1-4614-6625-3_34-1
- Suthar, S., Des, S., Nagpure, A., Madhurantakam, C., Tiwari, S. B., Gahlot, P., & Tyagi, V. K. (2021). Epidemiology and diagnosis, environmental resources quality and socio-economic perspectives for COVID-19 pandemic. *Journal of Environmental Management*, 280, 111700.
- Swan, D. A., Bradis, C., Janes, H., Moore, M., Matriaji, L., Reeves, D. B., Burns, E., Donnell, D., Cohen, M. S., & Schiffer, J. T. (2021). COVID-19 vaccines that reduce symptoms but do not block infection need higher coverage and faster rollout to achieve population impact. *Scientific Reports*, 11(1), 15531.
- Teslya, A., Pham, T. M., Godijk, N. G., Kretzschmar, M. E., Bootsma, M. C. J., & Rozhnova, G. (2020). Impact of self-imposed prevention measures and short-term government-imposed social distancing on mitigating and delaying a COVID-19 epidemic: A modelling study. *PLOS Medicine*, 17(7), e1003166. <https://doi.org/10.1371/journal.pmed.1003166>
- Tian, Y., Tsendbazar, N.-E., van Leeuwen, E., Fensholt, R., & Herold, M. (2022). A global analysis of multifaceted urbanization patterns using Earth Observation data from 1975 to 2015. *Landscape and Urban Planning*, 219, 104316.
- Vaillancourt, A., & Haavisto, I. (2016). Country logistics performance and disaster impact. *Disasters*, 40(2), 262–283. <https://doi.org/10.1111/disa.12146>
- Wang, Q., Liu, Z., Jiang, P., & Luo, L. (2022). A stochastic programming model for emergency supplies pre-positioning, transshipment and procurement in a regional healthcare coalition. *Socio-Economic Planning Sciences*, 82, 101279.
- Weffens, P. J. J. (2020). Macroeconomic and health care aspects of the coronavirus epidemic: EU, US and global perspectives. *International Economics and Economic Policy*, 17(2), 295–362. <https://doi.org/10.1007/s10368-020-00465-3>
- Wells, C. R., Sah, P., Moghadas, S. M., Pandey, A., Shoukat, A., Wang, Y., Wang, Z., Meyers, L. A., Singer, B. H., & Gahrani, A. P. (2020). Impact of international travel and border control

- measures on the global spread of the novel 2019 coronavirus outbreak. *Proceedings of the National Academy of Sciences*, 117(13), 7504–7509. <https://doi.org/10.1073/pnas.2002616117>
- Wilder-Smith, A., & Osman, S. (2020). Public Health Emergencies of International Concern: A Historic Overview. *Journal of Travel Medicine*, 27(8). <https://um.kb.se/resolve?um=um:nbn:se:umu:diva-178321>
- World Bank. (2023). *Logistics Performance Index (LPI)*. <https://lpi.worldbank.org/international/global>
- World Health Organization. (2024, May 11). *COVID-19 cases | WHO COVID-19 dashboard*. <https://data.who.int/dashboards/covid19/cases>
- World Health Organization. (2022). *Global health sector strategies on, respectively, HIV, viral hepatitis and sexually transmitted infections for the period 2022-2030*. World Health Organization.
- Yu, D., Li, X., Yu, J., Shi, X., Liu, P., & Tian, P. (2021). Whether urbanization has intensified the spread of infectious diseases—Renewed question by the COVID-19 pandemic. *Frontiers in Public Health*, 9, 699710.
- Zhang, Y. (2022). How economic performance of OECD economies influences through green finance and renewable energy investment resources? *Resources Policy*, 79, 102925.
- Zhang, Y., Ding, Q., & Liu, J.-B. (2022). Performance evaluation of emergency logistics capability for public health emergencies: perspective of COVID-19. *International Journal of Logistics Research and Applications*, 25(12), 1509–1522. <https://doi.org/10.1080/13675567.2021.1914566>