Using the Kano model to associate the number of confirmed cases of COVID-19 in a population of 100,000 with case fatality rates: an observational study

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Research article

Keywords: infection rate; COVID-19; Kano model; total confirmed case; case fatality rate; Google Maps

Posted Date: April 29th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-23249/v1>

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Abstract

Background: One of the key factors to understand the spread of COVID-19 is the case fatality rate(CFR) rates for counties/regions. However, many merely reported those CFRs on the basis of total confirmed cases(TCC) instead of per population of 100, 000. As such, the disparate definitions of CFR yield inconsistent results in COVID-19 situations. Whether both incident rate and the CFR can be indicators to identify a country/region hit by COVID-19 under(or out of) control is still unclear.

This study aims to (1) develop a diagram to disperse both TCC and CFR on a population base of 100,000(namely TCC100 and CFR100, respectively) using the Kano model, (2)discuss selected countries/regions with success on preventative measures to keep COVID-19 under control(i.e., relatively lower TCC100 and CFR100 or CFR), and (3) design an app to display both TCC100 and CFR100 or CFR for all infected countries/regions.

Methods: We downloaded the COVID-19 data of confirmed cases and deaths in countries/regions on a daily basis from the Github website. Three values, TCC100, CFR100, and CFR, were computed for each country/region and displayed on the Kano model. The lower TCC100 and CFR values were deemed as having the COVID-19 situation more under control. An app was developed to display both TCC100 and CFR100 on Google Maps.

Results: The correlation coefficient(CC) between TCC100 and CFR100 is 0.92($t=37.87$) based on 285 count data (i.e., 12, 225, and 48 dispersed on the Kano diagram) obtained in comparison to the pair of TCC100 and CFR with the $CC=-0.02$ ($t=-0.25$) and counts(i.e., 56, 145, and 84 on the Kano diagram). The state of Washington, USA, was found having the highest TCC100(=3498.15), CFR100 (=16548.96) and CFR(=5%) in comparison to (1)Taiwan[TCC100(=1.65), CFR100 (=2.17), CFR(=1%)] and (2)South Korea[TCC100(=20.34), CFR100 (=39.8), CFR(=2%)] on April 12,2020.

Conclusion: We illustrated both TCC100 and CFR along with CFR100 to compare countries/regions on a Kano diagram to understand the COVID-19 situations better. A larger TCC100 value was strongly associated with a larger CFR100 value that needs further verifications in the future. An app was developed to display both TCC100 and CFR for countries/regions on a dashboard laid over Google Maps.

Background

When a new disease(e.g., COVID -19) spreads, one of the most commonly asked questions is: How high is the case fatality rate(CFR), defined as the total number of deaths known divided by the total number of known cases confirmed up until present time[1]? The CFR is related to the following questions: (1) How deadly is the disease? and (2) How many people will die during this outbreak?[2]. SARS, MERS, Ebola and H1NI yielded real case fatality rates(CFR) of 9.6%, 34.4%,73%, and 0.4%, respectively[5-9]. Thus, the CFR for COVID-19 is of interest to numerous researchers[1,3, 4].

1.1 Comparing CFRs and incidence rates on a specific population

Over 5,054 articles can be found based on the keywords “case fatality rate” in Pubmed Central(PMC)[5]. The incidence rate of an invading disease adjusted to a population of 100,000 was suggested in the literature[6-10]. As of April 12, 2020, none were found incorporating CFR with both CFR100 and total confirmed cases(TCC) on a population of 100,000(here we name CFR100 and TCC100, respectively) in a study. For instance, Italy had a high CFR at 13% for COVID-19 up until April 12, 2020. If taking the resident densities of each population into account, numerous countries/regions that surpassed Italy in both CFR100 and TCC100 require further investigations.

Furthermore, reports on the successes of Taiwan[11-13] and Vietnam’s prevention measures [14-23] can aid in verifying the preciseness of CFR(or CFR100) and TCC100 that are worth mentioning in COVID-19 reports with “particular tolls”. . .

1.2 The Kano model used for comparisons

The Kano Model is based on a theory of product development and customer satisfaction developed in 1984 by Professor Noriaki Kano[24], who classifies products or items into three main categories of quality: must-be, one-dimensional, and attractive.

Numerous articles were found using the keywords “Kano Model” [Title/Abstract] in PMC, with the following results: Hospital burn service providers were required to measure patient satisfaction with their care and categorize the services[25]. A cross-sectional study was conducted at Student Health Services of the Missouri University of Science and Technology, where the data were collected using the Kano survey[26]. Healthy fast-food chain restaurants sought to differentiate themselves from other fast-food restaurants and understand how customers perceive service attributes using the Kano Model[27].

Other relevant studies had applied the Kano Model to the importance-performance analysis (IPA) using four quadrants to display results in the literature[8-10] The challenges they experienced were (1) it was tedious to draw the plot; and (2) it was cumbersome to categorize the products or items when the Kano approach was applied.

1.3 How to draw the Kano model on Google Maps

The authors[31] presented codes in 2018 that allowed practitioners to classify entities according to the Kano framework and plot the results for rapid inspection and visualization. However, the code was written in R, a computer language not familiar to the public. Furthermore, the results were shown on a static plot instead of on an animated dashboard that allows users to easily identify the product (or item) of interest on their own. As such, processing and analyzing this type of data is currently very cumbersome, tedious, and prone to human error in classification and drawing when the Kano Model or IPA is applied.

The lack of dedicated software solutions may substantially limit the applications of the Kano Model to prove value in healthcare settings. To narrow the gap, we are motivated to present an easier way to

display the COVID-19 situations on CFR and TCC100.

1.4 Objectives

In this study, we programmed codes for (1) visualizing the Kano diagram to categorize the CFR and TCC100 for countries/regions and (2) illustrating the selection of COVID-19 situations under control and out of control.

Methods

2.1 Data sources

We downloaded COVID-19 outbreak data from Github [32], a site that contains information on confirmed cases and deaths in infected countries/regions up until April 12, 2020. All downloaded data(see Additional File 1) were publicly deposited on the website[32]. Ethical approval was not necessary for this study because all the data were obtained from the Google Sheets.

2.2 Quantitative Kano modeling

Although originally a qualitative method [24], quantitative extensions of the Kano Model have been proposed to increase its actionability and applications[33,34]. A quantitative Kano contains features in the top, middle, and bottom panels for entities[35]. The results of two domains (e.g., CFR on Axis Y and TCC100 on Axis X) should be re-coded as coordinates and displayed on a plot. In the current study, the Google Maps platform was integrated to demonstrate the Kano approach in displaying COVID-19 situations globally.

2.3 Computations step by step

In this section, two types of computer codes were developed. The Kano plot performs two main tasks: (1) plotting of boundary curves, and (2) classification of entities onto the Kano diagram.

(1) Plotting of boundary curves

The basic function of a curve (named hyperbola as upper and lower limited curves) was derived as $y = (x^2x - 3^*x)/(2^*x - 2)$, where y denotes the latitude on Google Maps, and x represents the longitude. The rotation for a specific point at p(x,y) can be made from the equations $y' = y*\cos\theta + x*\sin\theta$ and $x' = x*\cos\theta - y*\sin\theta$, where we are only concerned with the new position of y' instead of x', due to x being anchored and fixed to reflect the new position at p'(x, y').

(2) Classification of entities onto Kano classes

We programmed computer codes to classify entities or members into to classes according to their coordinates on a map. The method applied the formula for forming a line with two points (Li: $y = ax + b$).

We assumed that L_i is one of the many lines from L_1 to L_n as the upper limit of the one-dimensional category. If one entity is located at $p(4, 3)$, we can localize it within the two points $(-2, 14)$ and $(4, -4)$ based on the Axis X. That is $-2 < 4 \leq 4$. The simultaneous program composed by $y_1 = ax_1 + b$ and $y_2 = ax_2 + b$ is used for solving the parameters of a and b in L_i .

By subtracting y_2 from y_1 mentioned above, we get $a = -3$ and $b = 8$. As a result, Line Z can be represented by the equation: $y = -3x + 8$. The entity at $p(4, 3)$ can be referred to Line Z using the horizontal coordinate at 4 to yield a vertical coordinate of -4 on Line Z. Herein, we assign the entity as the attractive category due to the fact that the vertical coordinate 3 is higher than the standard -4 on Line Z. Similarly, we can further apply this principle to determine whether the entity is located in either the one-dimensional or the must-be quality category when the vertical coordinate is below the upper limit.

2.4 The corporates of CFR100 and TCC100 on the Kano diagram

Two Axes (i.e., CFR on Y and TCC100 on X) as coordinates were plotted on the Kano diagram. Bubbles were colored by the features (i.e., must-be, one-dimensional, and attractive) and bubble sizes determined by the CFR100.

2.5 A dashboard on Google Maps to present the CFR100 and TCC100

A dashboard was developed to display the daily results across various regions. An app was developed to display both TCC100 and CFR100 on Google Maps.

The numbers of entities in the three panels in the Kano diagram were computed. The correlation coefficient (CC) and the t-value $[=CC(\sqrt{n-2})/(1-CC^2)]$, where n is the number of entities] for all entities were calculated.

The study flowchart is presented in Figure 1.

Results

3.1 Using Kano model to display three features on Google Maps

The CC between TCC100 and CFR100 was calculated to be 0.92 ($t=37.87$) with 285 count data (i.e., 12, 225, and 48 dispersed among the Kano diagram), as shown in Figure 2. In contrast, the pair of TCC100 and CFR has the $CC=-0.02$ ($t=-0.25$) and counts (i.e., 56, 145, and 84 on the Kano diagram shown in Figure 3.

The state of Washington, USA, was found having the highest TCC100 ($=3498.15$) and CFR100 ($=16548.96$) with CFR ($=5\%$) (Figure 2) in comparison to (1) Taiwan [TCC100 ($=1.65$), CFR100 ($=2.17$), CFR ($=1\%$)], South Korea [TCC100 ($=20.34$), CFR100 ($=39.8$), CFR ($=2\%$)], and Vietnam [TCC100 ($=0.26$), CFR100 ($=0$), CFR ($=0\%$)] up until April 12, 2020.

3.2 Taiwan example on COVID-19 under control

The evidence shows Taiwan's COVID-19 situation is under well control, as shown in the left-hand bottom corner of Figures 2 and 3. After May 14, 2020, most of the confirmed cases were imported cases from overseas citizens(86%) in the 20-29 age group, as shown in Figures 4 and 5. The top three cities/counties were Taipei, New Taipei City, and Taoyuan(Figure 6). Readers are encouraged to scan the QR-code in Figure 5 to obtain more details.

It is worth mentioning that of 393 confirmed cases, 338(86%) was imported from overseas, female (52.8%), asymptomatic and mild cases(71%), medium(21%), severe(7.5%) including 6 deaths. As of April 12, 2020, 12 were still in intensive care units. A total of 114 were discharged from hospitalization and totally released from quarantine[36].

Discussions

4.1 Principle findings

In this study, we observed that the CC between TCC100 and CFR100 is 0.92($t=37.87$) and $CC=-0.02$ ($t=-0.25$) between TCC100 and CFR. The former is as expected due to the strong association between TCC and CFR though both were divided by a common value of 100, 000. The latter presents none relationship between TCC100 and CFR. That is the reason why we need to simultaneously examine these two for understand the COVID-19 hit to countries/regions in comparison,

Washington, USA was found to have the highest TCC100(=3498.15) and CFR100 (=16548.96) with CFR(=5%) in comparison to (1)Taiwan[TCC100(=1.65), CFR100 (=2.17), CFR(=1%)] , South Korea[TCC100(=20.34), CFR100 (=39.8), CFR(=2%)] ,and Vietnam[TCC100(=0.26), CFR100 (=0), CFR(=0%)] up until April 12,2020.

4.2 What this finding adds to what we already knew

Numerous documents have reported using CFRs to compare death tolls of specific diseases[5]. The incidence rates and CFRs adjusted by a population of 100,000 can be reasonably compared with one other[6-10]. We made an effort to combine both CFR(or CFT100) and TCC100 on a dashboard, which is novel, innovative, and rarely seen in past literature. Such a design presents a new perspective on the current COVID-19 pandemic. For instance, Italy had a high CFR at 13% for COVID-19 up until April 12, 2020, but less than the state of Washington, USA, and other countries/regions in CFR100 if population density had been taken into account.

In addition, countries/regions that performed well on fighting against COVID-19 should be highlighted (e.g., see the left-hand bottom corner in Figures 2 and 3), namely Vietnam, Taiwan, Hawaii(US), or Fujian(China). The coordinate for entities will be automatically and immediately adjusted to an appropriate point on the dashboard once the data are updated.

4.3. What it implies and what should be changed

We illustrated Taiwan, one example of a success controlling the COVID-19 crisis, in Figures from 4 to 6. One article from NBC News[37] suggested that Taiwan learned from the experience of the 2003 SARS outbreak and its government and people were well prepared for this current crisis.

Of the nearly 200 countries and regions affected, Taiwan has the lowest incidence rate – around 5 in every 100,000 people– for a place that is located so close to China and with so much travel to and from[37-39]. It is worth noting that the Taiwan government mandates hospitals to test for and report cases of COVID-19. Such policy helped the government identify those infected, trace their social contact history, and isolate those that were in contact. Taiwan's government's measures to prevent community spread were steps ahead of the world, successfully containing the widespread of the disease, even well before Taiwan had its first confirmed case on Jan. 21, 2020[40-43].

Another noteworthy fact is that Taiwan's Centers for Disease Control(CDC) set up the Central Epidemic Command Center on Jan. 20, 2020, which quickly rolled out a series of epidemic control measures. *The command center not only investigates confirmed and suspected cases, but also works with ministries and local governments to coordinate the crisis response across Taiwan, such as allocating funds, mobilizing personnel and advising on disinfection policies in schools*[37]. On Jan. 26, 2020, Taiwan was the first country to ban direct flights from Wuhan and a handful of other Chinese cities. Five days after Taiwan confirmed its first case, the Taiwan government imposed border control restricting all non-citizens from entering via China[44-46], see Additional Files 2 and 3.

Moreover, the Taiwan health insurance system covering 99 percent of the country's population has been crucial in fighting the spread of the outbreak. Such a system thus allows everyone to have access to necessary medical attention without the financial burden when the infection is suspected[47-48].

Similarly, Vietnam's early preparation from the first days of the pandemic has resulted in its current success in containing the outbreak [11].

4.4. Strengths of this study

Three key features of this study are highlighted below: (1)both TCC100 and CFR100 can be complementary to the deficit of the traditional CFT used in the epidemiology of not taking the population density into account; (2) one-dimension category is verified with $CC=0.92(t=37.87)$ comprising a total of 285 count data (i.e., 12, 225, and 48 dispersed on the Kano diagram), which makes comparing countries/regions on COVID-19 situations easy; (3) an app developed to display the CFR and TCC100 online, complements the traditional dashboards which do not consider population density.

4.5. Limitations and future studies

There are several limitations to our study. First, although the data were downloaded from Github[32] on a daily basis, the criteria to determine confirmed cases may not be consistent around the globe, which may influence the CFR computations. For instance, the confirmed cases are from clinically diagnosed cases in Hubei since Feb. 14, 2020 [49].

Second, although we applied both CFR and TCC100 on a dashboard(Figure 3), the provisional CFRs merely were hidden behind their bubble sizes. A larger bubble stands for a higher CFR100, which might be complementary to the CFR in this matter.

Third, some biases may exist among the US regions. Original data were based on county and location(eg., such as Spokane County, WA(US), St. Louis County, MO(US), Suffolk County, NY(US), Ulster County, NY(US), Unassigned Location, VT(US), Volusia County, FL(US), Unknown Location, MA(US),etc.), all of which should be combined into their own corresponding States prior to computing the CFR100 and TCC100. Particularly, in the recent data from Github [32], many counties in the US were included separately, making the data arrangement more difficult.

Fourth, although we recommend using a population-based method (e.g., CFR100 and TCC100 in this study), the traditional CFR cannot be neglected because of its familiarity with the general public, despite the importance of infected population density being greater than total confirmed cases and CFR in nature. Finally, every government has its own strategy and policy against COVID19. We illustrated two examples(e.g., Taiwan and Vietnam), where successful measures were implemented to prevent the outbreak. Many other effective measures applied to fight against COVID-19, such as a need to limit human-to-human transmission, to rapidly identify, isolate, and provide optimized care for patients, to accelerate the development of diagnostics, therapeutics, and vaccines[50], should not be ignored. On the other hand, caution should be taken to minimize social disruption and economic impact through international, collaborative, and multisectoral approaches.

Conclusion

We illustrated both TCC and CFR100 along with CFR100 with bubble sizes in Figures to compare countries/regions on a Kano diagram to better understand the COVID-19 pandemic. The evidence of more TCC100 has strongly associated with CFR100 that is a merit good for further verifications in the future. An app was developed to display both TCC and CFR100 for countries/regions using a dashboard laid over Google Maps.

List Of Abbrevitions

CC= correlation coefficient

CFR=case fatality rate

CFR100=case fatality rate per 100000 populatio

IPA=importance-performance analysis

PMC=Pubmed Central

TCC=total confirmed cases

TCC100= total confirmed cases per 100000 populatio

Declarations

Ethics approval and consent to participate

Not applicable.

All data were downloaded from the website database at Github

Consent to publish

Not applicable.

Availability of data and materials

All data used in this study is available in Additional files.

Competing interests

The authors declare that they have no competing interests.

Funding

There are no sources of funding to be declared.

Authors' Contributions

SBS developed the study concept and design. JLJ, YT and WC analyzed and interpreted the data. SBS monitored the process of this study and helped in responding to the reviewers' advice and comments. TWC drafted the manuscript, and all authors provided critical revisions for important intellectual content. The study was supervised by TWC. All authors read and approved the final manuscript.

Acknowledgments

We thank Enago (www.enago.tw) for the English language review of this manuscript. All authors declare no conflicts of interest.

References

1. Majumder MS, Rivers C, Lofgren E, Fisman D. Estimation of MERS-Coronavirus Reproductive Number and Case Fatality Rate for the Spring 2014 Saudi Arabia Outbreak: Insights from Publicly Available Data. PLoS Curr. 2014 Dec 18;6. pii: ecurrents.outbreaks.98d2f8f3382d84f390736cd5f5fe133c.
2. Chang CS, Yeh YT, Chien TW, Lin JCJ, Cheng BW, Kuo SC. The computation of case fatality rate for novel coronavirus (COVID -19) based on Bayes' theorem: an observational. Medicien 2020; in print.

3. Kamigaki T, Oshitani H. Epidemiological characteristics and low case fatality rate of pandemic (H1N1) 2009 in Japan. *PLoS Curr.* 2009 Dec 20 [revised 2009 Jan 1];1:RRN1139.
4. Battegay M, Kuehl R, Tschudin-Sutter S, Hirsch HH, Widmer AF, Neher RA. 2019-novel Coronavirus (2019-nCoV): estimating the case fatality rate - a word of caution. *Swiss Med Wkly.* 2020 Feb 7;150:w20203
5. Over 5,054 articles were searched by the keywords case fatality rate. 2020/4/12 available at <https://pubmed.ncbi.nlm.nih.gov/?term=%22case+fatality+rate%22++&sort=pubdate>
6. Eton V, Schroeter A, Kelly L, Kirlew M, Tsang RSW, Ulanova M. Epidemiology of invasive pneumococcal and *Haemophilus influenzae* diseases in Northwestern Ontario, Canada, 2010-2015. *Int J Infect Dis.* 2017;65:27–33. doi:10.1016/j.ijid.2017.09.016
7. Ciruela P, Martínez A, Izquierdo C, et al. Epidemiology of vaccine-preventable invasive diseases in Catalonia in the era of conjugate vaccines. *Hum Vaccin Immunother.* 2013;9(3):681–691. doi:10.4161/hv.23266
8. Dalcin D, Sieswerda L, Dubois S, Ulanova M. Epidemiology of invasive pneumococcal disease in indigenous and non-indigenous adults in northwestern Ontario, Canada, 2006-2015. *BMC Infect Dis.* 2018;18(1):621. Published 2018 Dec 4. doi:10.1186/s12879-018-3531-9
9. Gyenwali D, Vaidya A, Tiwari S, Khatiwada P, Lamsal DR, Giri S. Pesticide poisoning in Chitwan, Nepal: a descriptive epidemiological study. *BMC Public Health.* 2017;17(1):619. Published 2017 Jul 3. doi:10.1186/s12889-017-4542-y
10. Wamala JF, Malimbo M, Okot CL, et al. Epidemiological and laboratory characterization of a yellow fever outbreak in northern Uganda, October 2010-January 2011. *Int J Infect Dis.* 2012;16(7):e536–e542. doi:10.1016/j.ijid.2012.03.004
11. Nguyễn HM. How is Vietnam fighting COVID-19 so effectively despite being a third-world country? 2020/4/12 available at <https://www.quora.com/How-is-Vietnam-fighting-COVID-19-so-effectively-despite-being-a-third-world-country>
12. Van Minh H. Proactive and Comprehensive Community Health Actions to Fight the COVID-19 Epidemic: Initial Lessons From Vietnam [published online ahead of print, 2020 Apr 3]. *J Rural Health.* 2020;10.1111/jrh.12430. doi:10.1111/jrh.12430
13. Thanh HN, Van TN, Thu HNT, et al. Outbreak investigation for COVID-19 in northern Vietnam [published online ahead of print, 2020 Mar 4] [published correction appears in *Lancet Infect Dis.* 2020 Mar 18;]. *Lancet Infect Dis.* 2020;S1473-3099(20)30159-6. doi:10.1016/S1473-3099(20)30159-6
14. Talovich V. How are there so few COVID-19 cases in Taiwan? 2020/4/12 available at <https://www.quora.com/How-are-there-so-few-COVID-19-cases-in-Taiwan>
15. Chang BB, Chiu TY. Ready for a long fight against the COVID-19 outbreak: an innovative model of tiered primary health care in Taiwan [published online ahead of print, 2020 Apr 7]. *BJGP Open.* 2020;bjgpopen20X101068. doi:10.3399/bjgpopen20X101068

16. Joob B, Wiwanitkit V. COVID-19 pneumonia in Taiwan [published online ahead of print, 2020 Apr 2]. *J Formos Med Assoc.* 2020;. doi:10.1016/j.jfma.2020.03.009
17. Lee CY, Wang PS, Huang YD, Lin YC, Hsu YN, Chen SC. Evacuation of quarantine-qualified nationals from Wuhan for COVID-19 outbreak - Taiwan experience [published online ahead of print, 2020 Apr 1]. *J Microbiol Immunol Infect.* 2020;S1684-1182(20)30083-9. doi:10.1016/j.jmii.2020.03.023
18. Lin C, Braund WE, Auerbach J, et al. Policy Decisions and Use of Information Technology to Fight 2019 Novel Coronavirus Disease, Taiwan [published online ahead of print, 2020 Mar 31]. *Emerg Infect Dis.* 2020;26(7):10.3201/eid2607.200574. doi:10.3201/eid2607.200574
19. Cheng HY, Li SY, Yang CH. Initial rapid and proactive response for the COVID-19 outbreak - Taiwan's experience. *J Formos Med Assoc.* 2020;119(4):771–773. doi:10.1016/j.jfma.2020.03.007
20. Chen TY, Lai HW, Hou IL, et al. Buffer areas in emergency department to handle potential COVID-19 community infection in Taiwan [published online ahead of print, 2020 Mar 20]. *Travel Med Infect Dis.*
21. Su YJ, Lai YC. Comparison of clinical characteristics of coronavirus disease (COVID-19) and severe acute respiratory syndrome (SARS) as experienced in Taiwan [published online ahead of print, 2020 Mar 14]. *Travel Med Infect Dis.* 2020;101625. doi:10.1016/j.tmaid.2020.101625
22. Husnayain A, Fuad A, Su EC. Applications of google search trends for risk communication in infectious disease management: A case study of COVID-19 outbreak in Taiwan [published online ahead of print, 2020 Mar 12]. *Int J Infect Dis.* 2020;S1201-9712(20)30140-5. doi:10.1016/j.ijid.2020.03.021
23. Wang CJ, Ng CY, Brook RH. Response to COVID-19 in Taiwan: Big Data Analytics, New Technology, and Proactive Testing [published online ahead of print, 2020 Mar 3]. *JAMA.* 2020;10.1001/jama.2020.3151. doi:10.1001/jama.2020.3151
24. Kano N, Seraku N, Takahashi F, Tsuji S. Attractive Quality and Must-Be Quality. *Journal of the Japanese Society for Quality Control* 1984; 41: 39-48.
25. Gómez Martín C, García Morato RA, de Los Reyes Cortés N, Fernández-Cañamaque JL, Holguín P. Patient satisfaction in a Spanish burn unit. *Burns.* 2019 Mar;45(2):341-347.
26. Materla T, Cudney EA, Hopen D. Evaluating factors affecting patient satisfaction using the Kano model. *Int J Health Care Qual Assur.* 2019 Feb 11;32(1):137-151.
27. Chen KJ, Yeh TM, Pai FY, Chen DF. Integrating Refined Kano Model and QFD for Service Quality Improvement in Healthy Fast-Food Chain Restaurants. *Int J Environ Res Public Health.* 2018 Jun 22;15(7).
28. Padilla-Fortunatti C, Rojas-Silva N, Arechabala-Mantuliz MC. Analysis of the difference between importance and satisfaction of the needs of family members of critical patients. *Med Intensiva.* 2019 May;43(4):217-224.
29. Izadi A, Jahani Y, Rafiei S, Masoud A, Vali L. Evaluating health service quality: using importance performance analysis. *Int J Health Care Qual Assur.* 2017 Aug 14;30(7):656-663.
30. Mohebifar R, Hasani H, Barikani A, Rafiei S. Evaluating Service Quality from Patients' Perceptions: Application of Importance-performance Analysis Method. *Osong Public Health Res Perspect.* 2016

Aug;7(4):233-8.

31. Atlason RS, Giacalone D. Rapid computation and visualization of data from Kano surveys in R. *BMC Res Notes*. 2018 Nov 28;11(1):839.
32. Google Sheet. Novel Coronavirus (2019-nCoV) Cases, provided by JHU CSSE. 2020/4/9 available at <https://github.com/CSSEGISandData/COVID-19>
33. Wang T, Ji P. Understanding customer needs through quantitative analysis of Kano's model. *Int J Qual Reliab Manag*. 2010;27(2):173–184. doi: 10.1108/02656711011014294.
34. Xu Q, Jiao RJ, Yang X, Helander M, Khalid HM, Oppertud A. An analytical kano model for customer need analysis. *Des Stud*. 2009;30(1):87–110. doi: 10.1016/j.destud.2008.07.001.
35. Sauerwein E, Bailom F, Matzler K, Hinterhuber HH. The kano model: how to delight your customers. *Int Work Sem Prod Econ*. 1996;1(4):313–327.
36. UDN news. Taiwan COVID-19 and intgerpretations up to April 12, 20220. 2020/4/13 available at <https://health.udn.com/health/story/120951/4488841>
37. Sui NBC news on what Taiwan can teach the world on fighting the coronavirus. 2020/3/10 available at <https://www.nbcnews.com/health/health-news/what-taiwan-can-teach-world-fighting-coronavirus-n1153826>
38. Hsieh VC. Putting resiliency of a health system to the test: COVID-19 in Taiwan. *J Formos Med Assoc*. 2020;119(4):884–885. doi:10.1016/j.jfma.2020.03.002
39. Cheng HY, Li SY, Yang CH. Initial rapid and proactive response for the COVID-19 outbreak - Taiwan's experience. *J Formos Med Assoc*. 2020;119(4):771–773. doi:10.1016/j.jfma.2020.03.007
40. Lin C, Braund WE, Auerbach J, et al. Policy Decisions and Use of Information Technology to Fight 2019 Novel Coronavirus Disease, Taiwan [published online ahead of print, 2020 Mar 31]. *Emerg Infect Dis*. 2020;26(7):10.3201/eid2607.200574. doi:10.3201/eid2607.200574
41. Lee CY, Wang PS, Huang YD, Lin YC, Hsu YN, Chen SC. Evacuation of quarantine-qualified nationals from Wuhan for COVID-19 outbreak - Taiwan experience [published online ahead of print, 2020 Apr 1]. *J Microbiol Immunol Infect*. 2020;. doi:10.1016/j.jmii.2020.03.023
42. Cheng SC, Fan Chiang YL, Huang CH, Hsu YN. Author reply to Letters to the Editor "COVID-19 pneumonia in Taiwan" [published online ahead of print, 2020 Apr 2]. *J Formos Med Assoc*. 2020;. doi:10.1016/j.jfma.2020.03.011
43. oob B, Wiwanitkit V. COVID-19 pneumonia in Taiwan [published online ahead of print, 2020 Apr 2]. *J Formos Med Assoc*. 2020;. doi:10.1016/j.jfma.2020.03.009
44. Chen CC, Chi CY. Biosafety in the preparation and processing of cytology specimens with potential coronavirus (COVID-19) infection: Perspectives from Taiwan [published online ahead of print, 2020 Apr 7]. *Cancer Cytopathol*. 2020;10.1002/cncy.22280. doi:10.1002/cncy.22280
45. Chang BB, Chiu TY. Ready for a long fight against the COVID-19 outbreak: an innovative model of tiered primary health care in Taiwan [published online ahead of print, 2020 Apr 7]. *BJGP Open*. 2020;bjgpopen20X101068. doi:10.3399/bjgpopen20X101068

46. Chang BB, Chiu TY. Ready for a long fight against the COVID-19 outbreak: an innovative model of tiered primary health care in Taiwan [published online ahead of print, 2020 Apr 7]. BJGP Open. 2020;bjgpopen20X101068. doi:10.3399/bjgpopen20X101068
47. Hsiao SH, Chen TC, Chien HC, Yang CJ, Chen YH. Body Temperature Measurement to Prevent Pandemic COVID-19 in Hospitals in Taiwan: Repeated Measurement is Necessary [published online ahead of print, 2020 Apr 9]. J Hosp Infect. 2020;S0195-6701(20)30179-1. doi:10.1016/j.jhin.2020.04.004
48. Ou HT, Kao Yang YH. Community Pharmacists in Taiwan at the Frontline Against the Novel Coronavirus Pandemic: Gatekeepers for the Rationing of Personal Protective Equipment [published online ahead of print, 2020 Apr 13]. Ann Intern Med. 2020;M20-1404. doi:10.7326/M20-1404
49. BBC .Coronavirus: Sharp increase in deaths and cases in Hubei. 2020/2/14 available at <https://www.bbc.com/news/world-asia-china-51482994>
50. Xiao Y, Torok ME. Taking the right measures to control COVID-19 [published online ahead of print, 2020 Mar 5]. *Lancet Infect Dis*. 2020;. doi:10.1016/S1473-3099(20)30152-3

Additional Files

Additional File 1:

Xlsx file: study dataset

Additional File 2:

MP4 file: Taiwan against COVID-19

https://youtu.be/DA_WAkdDqY0

Additional File 3:

Dashboard of Taiwan CO VID-19 at

<https://viator.maps.arcgis.com/apps/opsdashboard/index.html#/bbd3dfeec9c494daf178457c7b74c3e>

Figures

Figure 1

Study flowchart

Figure 2

TCC100 and CFR100 on the Kano diagram($\text{corr.}=0.92$, $t=37.87$)

Figure 3

TCC100 and CFR on the Kano diagram($\text{corr.}=-0.02$, $t=-0.25$,)

Outside Taiwan   Inside Taiwan

Figure 4

Comparison of confirmed cases come from outside and inside Taiwan

Figure 5

Distribution of confirmed cases for age groups in Taiwan

Figure 6

Distribution of confirmed cases across Taiwan cities/counties

Supplementary Files

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