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TransJakarta Service Evaluation in Controlling COVID-19 Transmission Using Twitter Sentiment Analysis

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Abstract. *This study attempted to understand passenger perception of using public transport by utilizing Twitter data about the services of the TransJakarta Busway. Tweets were the main data source to capture users' responses toward these services. Users' perceptions were analyzed by sentiment analysis using a naïve Bayes algorithm. Furthermore, content analysis was used to inform improvements in service maintenance. The findings showed that the pandemic had a major impact on TransJakarta services, from a decrease in users, route closures, and fleet reductions to changes in user behavior. Most Tweets were negative regarding (1) poor bus frequency, leading to long queues and passenger overcrowding at bus stops and inside buses; (2) failure to maintain social distancing measures; (3) frequent violations of the 50% bus capacity reduction during peak hours, and showing a lack of consideration in measuring demand size during peak hours; (4) staff's weak control of implementing the health protocol exacerbated poor services. This study suggests service improvement based on peak hour demand analysis to offset the implications of a 50% capacity restriction by providing proper bus frequencies and headway arrangements considerable enough to avoid crowding, followed by optimal monitoring of health protocol by staff. Tweet data may inform poor management in controlling the transmission of COVID-19 on public transportation. Hence, using Twitter data could replace conventional data collection methods like user interviews. Beneficial information from Tweet data can be captured at relatively low costs. Therefore, it may aid the evaluation of PPKM policy implementation to create more resilient public transportation during pandemics.*

Keywords. *COVID-19, Public Transport, Sentiment Analysis, TransJakarta, Twitter*

Abstrak. *Penelitian ini mencoba untuk memahami persepsi penumpang dalam menggunakan angkutan umum dengan memanfaatkan data Twitter tentang layanan TransJakarta Busway. Tweet adalah sumber data utama untuk menangkap tanggapan pengguna terhadap layanan ini. Persepsi pengguna dianalisis dengan analisis sentimen menggunakan algoritma naïve Bayes. Selanjutnya, analisis konten digunakan untuk menginformasikan perbaikan dalam pemeliharaan layanan. Temuan menunjukkan bahwa pandemi berdampak besar pada layanan TransJakarta, mulai dari penurunan pengguna, penutupan rute, dan pengurangan armada hingga perubahan perilaku pengguna. Sebagian besar Tweet negatif mengenai: (1) frekuensi bus yang buruk, menyebabkan antrian panjang dan kepadatan penumpang di halte bus dan di dalam bus; (2) kegagalan untuk menjaga jarak sosial; (3) seringnya terjadi pelanggaran pengurangan kapasitas bus sebesar 50% pada jam sibuk, yang menunjukkan kurangnya pertimbangan dalam mengukur besaran permintaan pada jam sibuk; (4) lemahnya kontrol petugas terhadap penerapan protokol kesehatan sehingga memperparah pelayanan yang buruk. Studi ini menyarankan peningkatan*

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layanan berdasarkan analisis permintaan jam puncak untuk mengimbangi implikasi pembatasan kapasitas 50% dengan menyediakan frekuensi bus yang tepat dan pengaturan headway yang cukup besar untuk menghindari kepadatan diikuti dengan pemantauan protokol kesehatan yang optimal oleh staf. Data Tweet dapat menginformasikan manajemen yang buruk dalam mengendalikan penularan COVID-19 di transportasi umum. Oleh karena itu, menggunakan data Twitter dapat menggantikan metode pengumpulan data konvensional seperti wawancara pengguna. Informasi yang bermanfaat dari data Tweet dapat ditangkap dengan biaya yang relatif rendah. Dengan demikian, dapat membantu evaluasi implementasi kebijakan PPKM untuk menciptakan transportasi publik yang lebih tangguh di masa pandemi.

***Kata kunci**. Analisis Sentimen, Angkutan Umum, COVID-19, TransJakarta, Twitter*

Introduction

The first COVID-19 case was identified in Jakarta on 2 March 2020. This disease resulted in significant changes in daily life, for example by implementing health protocols. Such as using mandatory masks and maintaining distance between people in public places to limiting capacity in closed rooms and periodic sterilization to stay-at-home recommendations and not traveling for non-essential purposes. The government of Jakarta also implemented *Pembatasan Sosial Berskala Besar* (PSBB/Large-scale Social Restrictions) and *Pemberlakuan Pembatasan Kegiatan Masyarakat* (PPKM/Community Activities Restriction Enforcement) to prevent the spread of COVID-19.

These measures eventually affected the TransJakarta Busway services, as shown in Figure 1, with a decrease in monthly ridership of 66% monthly on average from January 2020 to August 2021, when the pandemic struck Indonesia. Easing the PSBB and implementing the transitional PSBB (*PSBB Transisi*) increased the number of TransJakarta passengers with strict health protocols. Even though the number of passengers in the following months increased, it did not reach half the number for the first month of the recorded year (January 2020). In July 2021, when the second wave of COVID-19 struck, the number of TransJakarta passengers decreased by almost half from the previous month. This was due to the implementation of the emergency PPKM (*PPKM Darurat*), which required 100% work from home in most sectors and limited citizens' mobility. The fluctuation of monthly TransJakarta ridership is shown in Figure 1 and Table 1.

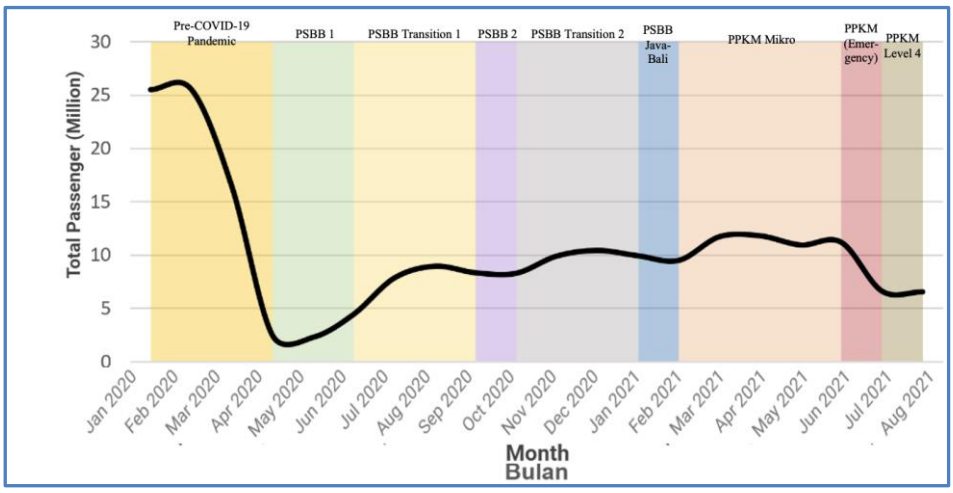

Figure 1. Monthly TransJakarta ridership in January 2020 – August 2021

Table 1. TransJakarta Monthly Ridership Changes in different government directives on traveling

Mobility Restriction Period	Month	Number of ridership	Changes from the prior month (%)	Change from the initial period (Pre-COVID)
Pre-COVID pandemic (Jan-Feb 2020)	Jan-20	25,549,326		
	Feb-20	25,593,242	0.17	0.17
First COVID-case identified	Mar-20	16,464,728	-35.67	-35.56
PSBB (Large-Scale Social Restrictions) I	Apr-20	2,493,546	-84.86	-90.24
	May-20	2,317,312	-7.07	-90.93
	Jun-20	4,482,037	93.42	-82.46
Transition PSBB I	Jul-20	7,887,252	75.97	-69.13
	Aug-20	8,986,980	13.94	-64.82
	Sep-20	8,370,936	-6.85	-67.24
PSBB II	Oct-20	8,325,094	-0.55	-67.42
Transition PSBB II	Nov-20	9,947,832	19.49	-61.06
	Dec-20	10,468,905	5.24	-59.02
	Jan-20	9,963,880	-4.82	-61.00
PSBB Java - Bali	Feb-21	9,536,314	-4.29	-62.67
Micro PPKM (neighborhood-scale)	Mar-21	11,758,101	23.30	-53.98
	Apr-21	11,841,259	0.71	-53.65
	May-21	10,977,379	-7.30	-57.03
	Jun-21	11,229,403	2.30	-56.05
Emergency PPKM	Jul-21	6,648,128	-40.80	-73.98
Level-4 PPKM	Aug-21	6,585,315	-0.94	-74.23
Average monthly changes				-65.58

Based on the table above evaluating TransJakarta services' performance to ensure passengers' comfort and safety amid the pandemic were necessary for PT Transportasi Jakarta as a service provider to understand passengers' perceptions of public transport during the COVID-19 period. In addition, it was expected that the evaluation results could be developed into priorities for improving TransJakarta services. Tweet data was an alternative way of collecting data for public service evaluation, which could be cheaper and easier than conventional methods such as interviews, questionnaires, and observation.

This study used Tweet data to capture public response regarding TransJakarta service by sentiment analysis. Using Tweet data was chosen because Tweets describe actual real-time conditions in large volumes (Yoon, Elhadad, and Bakken, 2013). Indonesia has the third-largest number of Twitter social-media users globally, at 24.3 million (Databoks.katadata.com, 2016), and most users are resided in Jakarta (Nugroho, 2020). The availability of abundant and accessible data from people (Syadid, 2019) makes Tweet (opinion) data an appropriate input for sentiment analysis. Another consideration for using Tweet data for this research was the tendency of people during the pandemic, when direct communication was limited, to use online contact via social media frequently (mediaindonesia.com, 2021).

This paper starts with an overview of TransJakarta as a BRT system in Jakarta which was affected by the COVID-19 pandemic, followed by theoretical reviews of relevant studies to better understand the context. This paper describes the impacts of COVID-19 on TransJakarta services based on the data gathered from PT Transportasi Jakarta's institutional survey, followed by identifying users' responses on Twitter towards TransJakarta services during the pandemic. Public transportation service evaluation based on previous studies was also reviewed as the basis for the synthesis variable. The structure explains the methodology used in this study, further divided into data collection, sentiment analysis, and content analysis. Lastly, the priority areas for TransJakarta's improvement to adapt the service to the pandemic are discussed.

Literature Review

Using Twitter Data in Public Transportation for Perception Analysis Using Twitter

Twitter data has become a primary and very important data source available for researchers (Imran et al., 2015). Twitter data has been used for various research projects, such as disaster risk management for real-time early warning systems (Chatfield et al., 2013; Carley et al., 2016). Furthermore, Twitter data analysis is also used as a health communication technology, testing the value and accuracy of location information (Burton, et al, 2012). It is considered a reliable source of data for research, since it offers faster news (real-time) compared to conventional news channels (Imran et al., 2020) and can accumulate into millions of data (Kalyanam et al., 2016). Twitter has a well-documented Application Programming Interface (API) for accessing the Tweets available on its platform (Lamsal, 2000).

During the COVID-19 pandemic, a large body of research utilized Twitter data (Lamsal, 2020; Chen et al., 2020; Alrazaq et al., 2020, and Banda et al., 2020). Twitter data was used to understand the spatial and temporal dimensions of the public discourse about COVID-19, so that results from these data could be used to respond to the crisis more efficiently (Lamsal, 2020). In addition, Lamsal (2020) used a Twitter dataset for specific English-language Tweets and their sentiment scores. Lopez and Gallemore (2021) constructed an augmented multilingual Twitter dataset of Tweets from around the world from 22nd January 2020 to September 2021 (still continuously collected and routinely updated). According to the authors, their data allow researchers to conduct various analyses, such as observing sentiment changes in response to specific events, modeling the relationship between disease spread and the sentiment, tracking sentiments associated with particular persons, places, and actors related to the pandemic over time, and so on. Cuomo et al. (2021) conducted a longitudinal and geospatial analysis of COVID-19 Tweets during the early outbreak period in the United States. The Tweets were collected from the Twitter API public stream using keywords related to COVID-19. The geocoded Tweets were classified based on user self-reporting COVID-19 characteristics such as symptoms, revealing the longitudinal relationship between the Tweets and the number of active cases in the US. They found that Tweets containing symptoms or concerns about COVID-19 were valid predictors of the number of active COVID-19 cases as temporal distance increased.

A study about the main topics posted by Twitter users during the COVID-19 pandemic was carried out by Alrazaq et al., (2020). Using keywords such as "Corona," "2019-nCov," and "COVID-19", the authors collected Tweets within two months (2 February 2020 to 15 March 2020). They conducted sentiment analysis, extracted the mean number of reTweets, likes, and followers for each topic, and calculated the interaction rate per topic. They found twelve topics grouped into four central themes: (1) the origin of the virus; (2) the sources of the virus; (3) the impact of the virus on people, countries, and the economy; and (4) mitigation of the infection risk.

Tweet data studies related to public transport services were done by some researchers. Twitter, as a social media platform, can be used to increase the communication interaction between public transport providers and users (Purnomo et al., 2021 and Zhang, et al., 2022). Using Jakarta public transport services as a case study (LRT, MRT, BRT, and Commuter Line), the authors found five main contributions of Twitter data in delivering COVID-19 risk information, without revealing the effectiveness of the communication strategy and level of interaction through the number of reTweets, likes, and followers for each type of information. On the other hand, using the US context, Zhang et al. (2022) found that Twitter can be used as an effective media in COVID-19 risk communication and can improve public perception of the health and safety aspects of public

transport. They found that the count of average likes per Tweet was positively correlated with the percentage of COVID-related Tweets; however, it was negatively correlated with the percentage of Tweets discussing social distancing and the frequency of agency messages. The more the agency Tweeted, the higher the likelihood that interactions increased in terms of follower gains per Tweet, Tweets replying to followers, and Tweets using outlinks.

COVID-19 and Mobility

Many studies have pointed out the relationship between the COVID-19 pandemic and the phenomenon of mobility reduction. An enormous reduction in mobility occurred globally at 10-percentage point decrease in mobility led to a 30% fall in COVID-19 cases per capita in the US (Glaeser, Gorback, & Redding, 2020). In addition, the substantial mobility heterogeneity decreased across space and over time. On the other hand, some researchers believe confounding factors influenced the relationship between COVID-19 and mobility. For example, non-pharmaceutical interventions (NPI) in the form of government orders on mobility or government directives on travel restrictions was associated with the onset of the COVID-19 threat and significant mobility reduction (LIU et al., 2020, Nouvellet et al., 2021, Warren & Skillman, 2020).

In the Indonesian context, the mobility reduction varied across provinces and over time. On 1 June 2021, nine provinces experienced mobility reduction; on average, mobility increased relative to the benchmark date (February 2020) by 8%. As of 15 June 2021, thirteen provinces experienced mobility reduction. The average mobility decrease relative to the benchmark was –4%. However, the number spiked on 22 June 2021, whereas twenty provinces experienced mobility reduction with an average mobility compared to the benchmark of –7%. There was an apparent confounding factor from the mobility restriction policy during June 2021, known as PPKM, with a reduction in mobility and an increasing number of COVID-19 cases.

Public Transportation Service Operation

The literature on public transport service operations during COVID-19 has shown various actions for COVID-19 prevention and adaptation. Public transportation service providers worldwide took health measures and made multiple efforts to adapt to the risks. Public transport service providers had to promote changes in the internal system of transportation services (CDC, 2020 and Shen et al., 2020), such as equipping the transportation service officers with basic education about COVID-19, the preparation of specific supervision and prevention guidelines, the reduction of fleet frequency and enforcement of limited operating hours. In addition, there was strict implementation of health protocols found in many public transportation services. These included design intervention, physical distancing inside the bus or carriage, a good ventilation system development, temperature checks, the obligation to use masks both at stops and in the fleet, and provision of hand sanitizers and regular mass disinfection (Ang et al., 2020 and Vitrano, 2021).

In responding to the pandemic in terms of people's travel patterns, the Indonesian COVID-19 Task Force (2021) explained the provisions for using public transportation during the pandemic with health protocols that users had to adhere to. These provisions were contained in *Surat Edaran* No. 12/2021 concerning Travel Provisions for Domestic People during the Corona Virus Disease 2019 (COVID-19) Pandemic. In this regulation, every individual intending to travel was required to apply the '3M' health protocol, namely: *Memakai masker* (wearing a mask), *Menjaga jarak dan menghindari kerumunan* (maintaining distance and avoiding crowds), and *Mencuci tangan dengan sabun atau menggunakan hand sanitizer* (washing hands with soap or using a hand sanitizer).

Public Transportation Service Evaluation

Service can be defined as an activity or benefit offered by one party to another and is essentially intangible, and does not result in ownership of something that lasts for longer than a moment but can be felt by the recipient of the service (Hafid, 2017). In the context of public transportation, service providers must pay attention to the performance of the services provided to passengers. The level of service is the service provided to users in accordance with service standards that have been set as guidelines for providing services (Anastasia, Ari, and Agustin, 2015). In addition, service providers must refer to existing service performance indicators in serving passengers. Service performance indicators are an appropriate measure or method to achieve goals concerning economic and technical aspects (Rahmawati and Novitasari, 2010). Indicators can also be standards and benchmarks.

Furthermore, the performance of public transportation services was affected by the COVID-19 pandemic because in carrying out their services, public transportation service providers had to consider several indicators related to health protocols, such as the implementation of physical distancing and capacity restrictions. In addition, previous studies found that the quality of public transportation services decreased during the pandemic (Gaus et al., 2020), specifically the performance of the TransJakarta services. Kusumawardani (2020) explained that several indicators needed to be prioritized during the pandemic, such as crowd control (preventing crowding) maintaining physical distance and its arrangements by officers in the form of physical markers, and bus waiting times. These indicators were closely related to implementing health protocols during the COVID-19 pandemic.

Public transportation service evaluation is useful in understanding the achievement of existing goals and programs, measuring the success of implementation, and seeing the system's efficiency (Rizani, 2019). Evaluation can be carried out in two ways: based on user perception and feedback from an experienced evaluation team. In general, Parasuraman, Berry, and Zeithaml (1991) defined service quality measurement for transportation services known as SERVQUAL, where the analysis consists of five dimensions, i.e., reliability, responsiveness, assurance, empathy, and tangibles. Bus Rapid Transit service evaluation in Malaysia conducted by Mihnans, Shahid, and Hassan (2015) used the variables of reliability, transit service and facilities, bus fare, bus characteristics, conduct, information, and suitability based on users' perception. Mahmoud and Hine (2016) included security in evaluating city bus services. However, evaluating the BRT service on its performance of controlling the transmission of COVID-19-related variables, e.g., physical distancing, design interventions, etc., should be considered to measure how well public transportation performed in response to the pandemic.

In Indonesia, i.e., the government of DKI Jakarta created a minimum service standard for TransJakarta, as stipulated in DKI Jakarta Governor's Regulation No. 33/2017, later amended by DKI Jakarta Governor's Regulation No. 13/2019. TransJakarta had to comply with these indicators, which comprised basic services that must be delivered to the users, i.e., safety, security, comfort, accessibility, equality, and regularity.

Methodology

Data Collection

Twitter data was used as the primary data source. Data collection was conducted from May to August 2021, resulting in 29,772 Tweets. Data mining from Twitter was conducted with required

crawling criteria such as qualitative text in the Indonesian language (Bahasa) with the keywords "TransJakarta", "@PT_TransJakarta", and "Busway". These Tweets represented opinions from the general population that often uses Twitter within a radius of 25 km from the center point of Jakarta, located at the National Monument (6.1754°S, 106.8272°E). No specific criteria were applied regarding the demographic profile of Twitter users. In relation to data representativeness, according to data from PT Transport Jakarta (2020), 92.1% of TransJakarta service users use social media to communicate, 46.7% use Twitter platform. Consequently, Twitter data provides a unique way for those who are frequent users of social media to express their feelings, concerns, or information in TransJakarta-related Tweets. Hence, the Twitter users were self-selected as being concerned about specific issues related to TransJakarta service operation.

Tweet data was collected to capture general public sentiment towards TransJakarta relevant to the operation of its services during COVID-19. The data was retrieved from the Twitter database using the RStudio software. The data retrieval processes utilized the 'rTweet' library and four token access codes obtained from the previous Twitter API.

This research used secondary data, especially literature reviews and institutional surveys to enrich the findings. Secondary data was collected from relevant agencies, such as PT Transportasi Jakarta related to the operation of TransJakarta service before and after the COVID-19 pandemic, the service standards and the health protocols implementation. Data gathered from the institutional survey was used as inputs to identify the COVID-19 impacts on TransJakarta service.

Sentiment Analysis

Sentiment analysis was conducted as part of the text mining process. This type of analysis consisted of computational research of opinions, sentiments, and emotions that are expressed textually (Liu, 2010). In sentiment analysis, grouping the text in a document, sentence, or object was carried out to produce a value that expresses the author's attitude toward positive, neutral, or negative sentiments (Fitri, 2020). Thus, sentiment analysis can determine tendencies in public opinion from textual data. This analysis is widely used on issues in everyday life. However, in some contexts, sentiment analysis has also been performed by entrepreneurs to improve product quality according to users' sentiments (Gunawan et al., 2017). Additionally, government agencies have conducted sentiment analysis to evaluate the performance of public facilities and services and obtain opinions on a particular issue or topic concerning the services.

This paper identified the preliminary impacts of COVID-19 on TransJakarta services, followed by sentiment analysis to understand TransJakarta users' response towards the TransJakarta services amid the pandemic. The sentiment analysis was preceded by a text preprocessing analysis. The purpose of the text preprocessing analysis was to structure previously unstructured or arbitrary data into structured data ready for further processing (Jumeilah, 2017). In this study, the text preprocessing stage included case folding (removing URLs, emoticons, mentions, and hashtags), text replacement (replacing slang words), text stripping (removing all symbols), text stemming (removing affixes), tokenizing, and stop-word removal. In the preprocessing stage, RStudio was used. When the Tweet data was ready and cleaned, the data was labeled accordingly. During labeling, Tweets about substances unrelated to the research were deleted. The deletion was necessary to have only valid data for sentiment analysis. In addition, prior labeling was essential, since sentiment analysis is a supervised learning algorithm where the sentiments to be generated are derived from predicted data classification. This data was labeled with three types of sentiments (positive, negative, and neutral), except for Tweet data that went into the category of test data. In labeling the data, the Tweets were grouped manually based on their substance according to the seventeen variables in this research, as shown in Table 2.

Table 2. Variables Used

Indicator	Variable	Literature
Reliability	**1.** Bus operational time	Eboli and Mazzulla (2007), Alexopoulus and Wyrowski (2015), Minhans, Shahid, and Hassan (2015), and Mahmoud and Hine (2016)
	2. Bus service frequency (headway)	Eboli and Mazzulla (2007), Minhans, Shahid, and Hassan (2015), and Mahmoud and Hine (2016)
Comfort	**3.** Bus cleanliness	Eboli and Mazzulla (2007), Mahmoud and Hine (2016), Pergub DKI Jakarta 13/2019 (2019)
	4. Bus seat comfort	Minhans, Shahid, and Hassan (2015), Mahmoud and Hine (2016), and Pergub DKI Jakarta 13/2019 (2019)
Staff Provision	**5.** Staff availability in the bus fleet and at bus stops	Eboli and Mazzulla (2007) and Mahmoud and Hine (2016)
Health	**6.** Bus ventilation and air conditioning systems	Minhans, Shahid, and Hassan (2015), Pergub DKI Jakarta 13/2019 (2019), Permenhub 18/2020 (2020), Ang et al. (2020), and Vitrano (2021)
	7. Proper masks usage while on buses and bus stops	TransJakarta (2020), Permenhub 18/2020 (2020), Ang et al. (2020), and Vitrano (2021)
	8. Physical distancing implementation while on buses and at bus stops	TransJakarta (2020), Permenhub 18/2020 (2020), Ang et al. (2020), and Vitrano (2021)
	9. Provision of hand sanitizer in strategic locations on buses and at bus stops	TransJakarta (2020), Permenhub 18/2020 (2020), Ang et al. (2020), and Vitrano (2021)
	10. Provision of sinks in bus stops	TransJakarta (2020) and Permenhub 18/2020 (2020)
	11. Passenger and staff body temperature check at bus stops	TransJakarta (2020), Permenhub 18/2020 (2020), Ang et al. (2020), and Vitrano (2021)
	12. Cashless payment implementation	TransJakarta (2020), Ang et al. (2020), and Vitrano (2021)
	13. Provision of separators in seats in the buses	TransJakarta (2020), Ang et al. (2020), and Vitrano (2021)
	14. Crowd management by capacity restrictions in the buses	Eboli and Mazzulla (2007), Pergub DKI Jakarta 13/2019 (2019), TransJakarta (2020), Ang et al. (2020), and Vitrano (2021)
	15. Overcapacity bus stop closure	TransJakarta (2020)
	16. Acceleration of passenger circulation when entering and exiting buses and bus stops	TransJakarta (2020)
	17. Verbal and written advice from staff related to the implementation of health protocols and the dangers of COVID-19	Permenhub 18/2020 (2020), CDC (2020), and Shen et al. (2020)

After the division of seventeen variables, the data was analyzed using the WEKA software to derive sentiments in the following stages:

1. Dividing the entire dataset into two parts, namely 80% for training and validation, and 20% for testing. Napitulu (2020) conducted a similar study on evaluating the performance of public transportation services. Furthermore, the 80% of the data used for training and validation were used to test the validity before implementing the model to the testing data.

2. For the training data, each Tweet first had to be labeled manually as containing 'positive', 'neutral', or 'negative' sentiment.
3. After labeling all the training data, the data was run using WEKA to be studied regarding the classification of sentiments using a naïve Bayes classifier. This technique was chosen because the naïve Bayes algorithm performs better and more accurate than other classification algorithms, such as decision trees and neural networks. Naïve Bayes classifiers has shown high accuracy and speed when applied to large databases (Han and Kamber, 2006) and have a high degree of accuracy with simple calculations (Aggarwal and Zhai, 2012). In further processing, the data distribution was used as training and data validation by a k-fold cross-validation system. The K-fold cross-validation is a technique to test the validity of machine learning by dividing the data into K subsets. The performance of a Naïve Bayes classifier would have been better if combined with k-cross validation (Hubert et al., 2021). The value of K chosen in this study was ten, based on the research by Kohavi (1995), which suggested that the best number of folds is ten, for a validity test. In the ten-fold cross-validation process, the data was divided into ten subsets and then tested ten times, starting from the first iteration, where subset 1 became the data to be tested for validity, and so on.
4. Furthermore, the data validation was run using the Machine Learning Model trained by the classification of the training data set, and each labeled sentiment was temporarily removed during this stage so that the model could predict well.
5. The next step was to adjust the sentiment classification that the model had predicted with the classification that the authors had labeled manually, where confusion matrices were created to assess the accuracy of the model's prediction.
6. After the model was successfully created and knowing the level of accuracy, the remaining 20% of the total Tweets data included in the testing data category was analyzed using the resulting model.
7. The model's output in the unlabeled tested data automatically classified each Tweet, which was then measured for each variable. Overall Tweets from each variable was calculated as the sentiment to identify users' responses on Twitter towards the TransJakarta services during the pandemic.

The sentiment analysis results further informed priority areas for the TransJakarta services in controlling the transmission of COVID-19 according to users. The prioritized variables were chosen based on Tweet frequency, where variables with more than 120 occurrences during the study period were presented. However, Tweets with negative sentiments were the core focus of this research to inform priority improvement. Therefore, content analysis was conducted on each selected variable to identify the touch points needed to control the transmission of COVID-19 on the TransJakarta service.

Results and Discussion

Impacts of COVID-19 on TransJakarta Services

COVID-19 significantly affected the TransJakarta services, with data evidence gathered from an institutional survey from PT Transportasi Jakarta. For instance, the decline of the number of passengers after the COVID-19 pandemic can be seen from the time-series data from December 2018 to August 2021 (Figure 2). The average number of monthly passengers before COVID-19 (recorded more than 21 million per month) dropped by almost 160% during COVID-19 (recorded at around 8 million per month). The declining number of TransJakarta users was supported by

data on changes in consumer behavior due to the COVID-19 pandemic and the application of PSBB obtained from a satisfaction survey of TransJakarta service users in 2020. The survey showed a tendency of consumers preferring private modes of transportation such as online motorcycle taxis, conventional motorcycle taxis, and private cars/motorcycles, particularly those who had out-of-home activities with frequent trips (three to five times per week). Hence, passengers switched from TransJakarta to other paratransit modes during COVID-19.

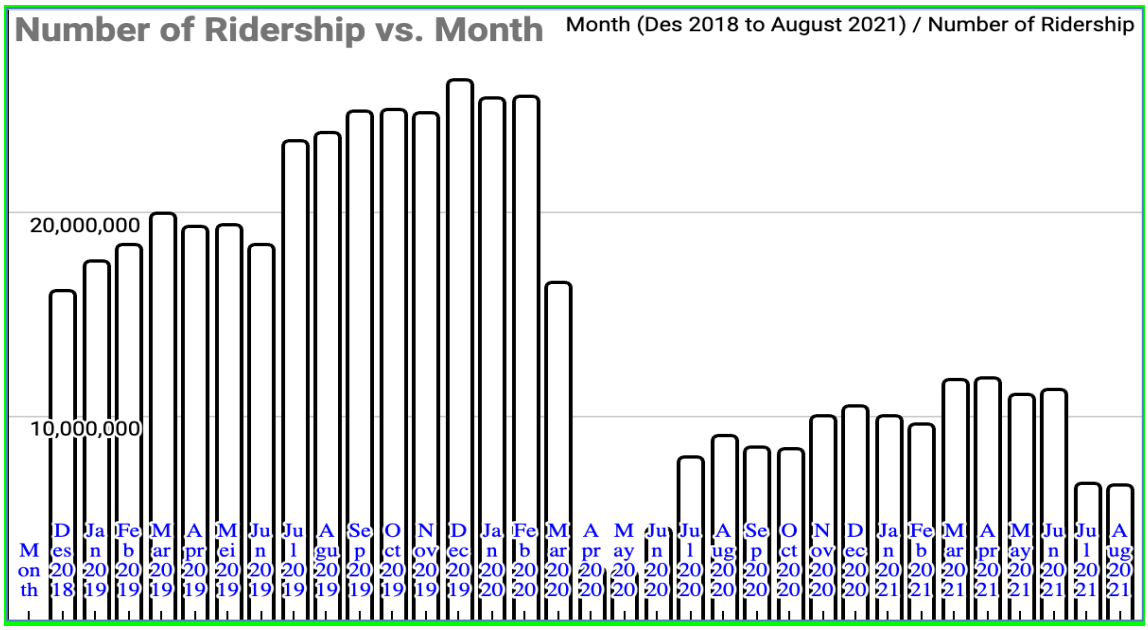

Figure 2. TransJakarta Monthly Ridership from December 2018 to August 2021

Table 3. Changes in TransJakarta Services Pre- and During-COVID-19 Pandemic

Pre-COVID-19 Pandemic	During-COVID-19 Pandemic
Operation for 24 hours	Reduction of operating hours from 06.00 to 18.00 (PSBB I) to 05.00 to 20.00 (*PPKM Mikro*)
No health protocol implemented	Implementation of health protocols, e.g.: • Provision of sanitation facilities • Implementation of safe distance between customers • Provision of separators between seats • Provision of special queues for medical officers • Advice not to talk/phone while on the bus • Applying cough and sneezing etiquette • Mandatory use of masks properly and correctly • Body temperature check before entering the TransJakarta environment • Obligation to show vaccine certification and worker registration letter when using TransJakarta services
Operation of all routes and corridors	Reduction of the number of routes but adding them gradually from only 13 main corridors (*PSBB I*) to 150 routes (*PPKM Mikro*)
Cash payments still available	Eliminate any cash transactions at bus stops and implement cashless transactions
No crowd management and capacity restrictions at all	Limitation on the maximum number of customers on the bus, namely 60 people for articulated buses, 30 people for large buses, and 15 people for medium buses

Bus routes and operations were also affected by the COVID-19 pandemic throughout the year. Mobility restrictions and advice for people to work or study from home significantly reduced bus routes and operations compared to pre-COVID-19. The monthly operating routes dropped from around 250 to less than 50 from May to June 2020. In addition, the number of operating buses decreased significantly from almost 4,000 buses per month to less than 500 in the same period. In 2021, the operation of TransJakarta routes and bus services increased again. For example, more than 150 routes and around 3,000 buses operated, but these operations never returned to pre-COVID-19 conditions.

The pandemic also made health protocol implementations very important, resulting in several changes from pre-pandemic to during-COVID-19, as shown in Table 3. The health protocol implemented by TransJakarta followed the regulations formulated by the Head of the DKI Jakarta Provincial Transportation Service (*Kadishub*).

Apart from the issues mentioned above, COVID-19 affected user demographics and behavior to some extent. Before the pandemic, the gender makeup of the users was balanced between men and women, while after the pandemic struck, women dominated the user gender demographic. The user behavior also changed after the pandemic, where more people traveled less with TransJakarta in terms of travel frequency as well as duration than before the pandemic.

User Responses on Twitter Towards TransJakarta Services during the COVID-19 Pandemic

A total number of 29,772 Tweets were collected based on the crawling criteria explained in the data collection section. After checking the contents, the dataset was reduced to 3,554 Tweets. The data was further categorized into 17 variables. Since several Tweets were categorized into more than one variable, the total number of Tweets in the final dataset was 4,027 Tweets to bewhich were further analyzed. Sentiment analysis was carried out by dividing the dataset into two parts, namely 80% training data (3761 Tweets) and 20% testing data (311 Tweets). Based on the performance testing results using the WEKA software, the model's accuracy was 86.68%, as shown in Table 4, containing the detailed validation measurements using a confusion matrix.

Table 4. Confusion Matrix

	Negative	Neutral	Positive
Negative	1,573	167	28
Neutral	183	1,614	20
Positive	71	32	71

After the remaining test data was classified using the model, the entire dataset was categorized into variables and sentiments. Table 5 shows the number of Tweets for each variable and the number of Tweets according to sentiment.

Regarding the total Tweets, the bus operational time variable had the highest number of Tweets (40.5% of all Tweets), followed by bus service frequency (19.3%). However, the highest percentage of negative sentiments emerged perceiving the bus service frequency variable. On the other hand, the provision of a mark separator was primarily appreciated by users with the highest percentage for positive sentiment. Tweets regarding bus operational time were 93.9%, with a total of 1,549 Tweets and dominated by users seeking information about operating hours by asking the official TransJakarta Twitter account. It was observed that during the study period (May to August 2020), based on the *Peraturan Gubernur* DKI Jakarta, there were four different operational hours.

Initially, TransJakarta operated until 22:00, but later it served until 20:30 due to the high number of COVID-19 cases in DKI Jakarta at the time of the study.

Table 5. Total Number of Tweets for Each Variable and Sentiment

Variable	Negative	Neutral	Positive	Total	Percentage
Bus operational time	83	1549	18	1650	40.5%
Bus service frequency (headway)	609	141	34	784	19.3%
Bus cleanliness	334	13	22	369	9.1%
Bus seat comfort	249	45	11	305	7.5%
Staff availability in the bus fleet and at stops	241	16	26	283	6.9%
Bus ventilation and air conditioning system	84	153	23	260	6.4%
Proper mask usage while on buses and at bus stops	69	31	7	107	2.6%
Physical distancing implementation while on buses and at bus stops	54	8	16	78	1.9%
Provision of hand sanitizer in strategic locations on buses and at bus stops	51	16	4	71	1.7%
Provision of sinks at bus stops	28	6	6	40	1.0%
Passengers and staffs body temperature checks at bus stops	31	1	6	38	0.9%
Cashless payment implementation	10	15	1	26	0.6%
Provision of separators between seats on the buses	20	3	2	25	0.6%
Crowd management by capacity restriction on the buses	12	6	0	18	0.4%
Overcapacity bus stop closure	5	2	3	10	0.2%
Acceleration of passenger circulation when entering and exiting buses and bus stops	2	1	1	4	0.1%
Verbal and written advice from staff related to the implementation of health protocols and the dangers of COVID-19	4	0	0	4	0.1%
Total	1,886	2,006	180	4072	

The total number of Tweets in each month of observation were divided according to sentiment as shown in Figure 3. In May 2021, TransJakarta users utilized Twitter most frequently. This was related to the policy where TransJakarta services were still operating more broadly. Hence, many people still used the TransJakarta services compared to the following three months when the second wave of COVID-19 hit Indonesia. Negative sentiment peaked in June 2021 with as many as 832 Tweets, while neutral sentiment mostly occurred in May 2021, the same as positive sentiment. Positive sentiment was the lowest in number among the other two sentiments, with only 180 Tweets in 4 months. The total number of Tweets from TransJakarta users during the study period was in May 2021, with 1,570 Tweets, and in July 2021, with 528 Tweets.

The mobility restriction influenced the number of Tweets and the number of negative sentiment Tweets due to the spike in COVID-19 cases in DKI Jakarta. Table 6 presents the association between the mobility policy for public transport, the change in ridership as well as the total number of Tweets and the number of negative Tweets from May 2021 to August 2021. While there were not changes in the mobility policy for TransJakarta, the significant decrease in ridership was directly associated with the spike increases in positive COVID-19 cases due to the

Delta-type virus, forcing workers to work from home. Thus, the number of Tweets and negative sentiments also decreased due to the vast reduction in TransJakarta ridership.

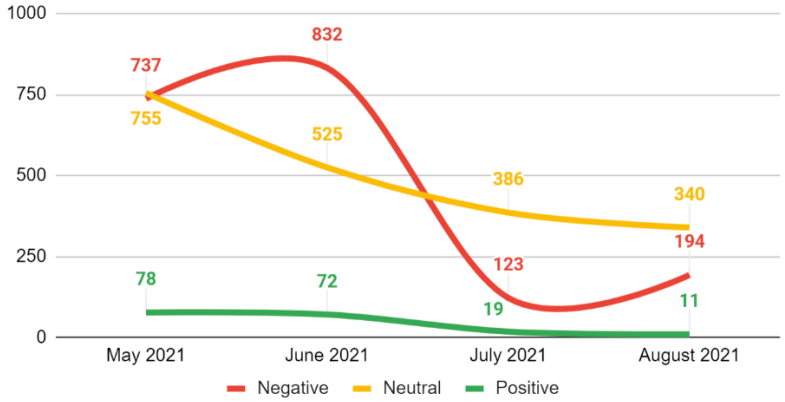

Figure 3. Total Number of Tweets In Each Month of Observation and Sentiment Classification.

Table 6. Association Between Policy on Mobility Restriction and Sentiments

Implementation of mobility restriction	**Policy applied for public transport**	**Number of BRT ridership**	**Number of positive COVID cases**	**Number of Tweets**	**Number of negative sentiment Tweets**
PPKM (Community Activity Restriction Enforcement) - Micro (neighborhood-scale) (May-June 2021)	50% of public transport capacity Operation hours: 05am to 10pm.	11.1 million monthly average (reduction of 55% from before COVID-19)	Monthly cases on average 70,000	1,500 Tweets	Monthly average 785 Tweets (52.3%)
Emergency PPKM (July 2021)	50% of public transport capacity Operation hours: 05am to 08.30 pm. Ability to show letter of employment registration (STRP, *Surat Tanda Registrasi Pekerja*)	6.65 million (reduction of 74% from before COVID-19)	More than 265,000 cases	528 Tweets	123 Tweets (23.3%)
Level-4 PPKM (August 2021)	50% of public transport capacity Operation hours: 05am to 08.30 pm. Showing proof of vaccine certificate on site	6.6 million (reduction of 74% from before COVID-19)	More than 33,000 cases	545 Tweets	194 Tweets (35.6%)

Priority Areas for TransJakarta Services in Controlling the Transmission of COVID-19

Priority areas for the TransJakarta services in preventing the transmission of COVID-19 were identified based on the previous sentiment analysis results. The use of content analysis and the consideration explained in the methodology part revealed four prioritized variables: (1) bus

frequency service (headway); (2) physical distancing implementation; (3) crowd management by capacity restrictions; and (4) staff availability both in the fleet and at bus stops. These areas were identified as priorities since the interrelationship between areas of concern from users leads to poor management of COVID-19 transmission in public transport as shown in Figure 4.

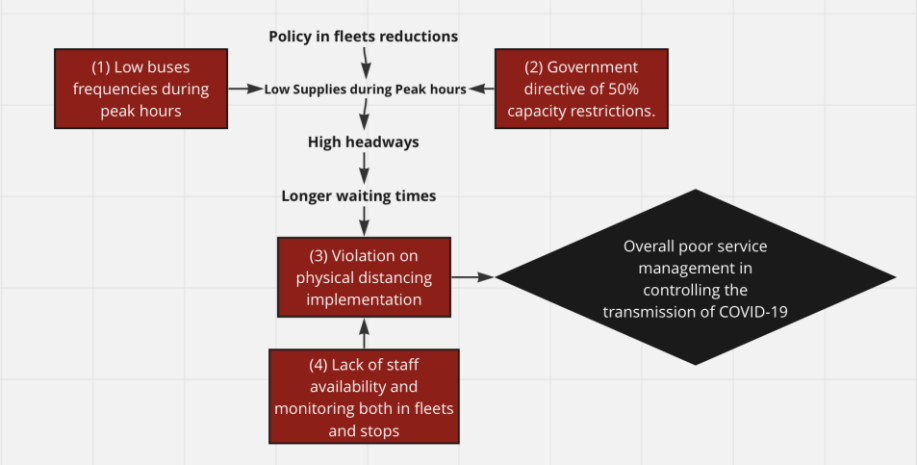

Figure 4. The interrelationship between issues (area of concern of users) that dictate the four priorities of service improvement.

Regarding the on-bus frequency service variable, it was found that there were several topics in the form of negative opinions relating to service performance on this variable that were discussed by TransJakarta users on Twitter, such as:

(1) High bus headway results in long queues and passengers crowding up at stops.

(2) Small fleets with longer waiting times, especially during rush hour.

(3) The unbalanced frequency between corridors in TransJakarta, while small fleets served the corridors.

The impact of only a few buses available to cater to many users, especially during peak hours, resulted in difficulties implementing health protocols. It also made it difficult for passengers to maintain a safe distance. Eventually, this led to poor management in controlling the transmission of COVID-19. The physical distancing implementation variable was also related to the previous variable, where many people spoke about the passengers being crammed into buses without any social distancing measures. Most of them sat side by side without restrictions. The third variable, capacity restrictions, spoke about not having capacity restrictions at both bus stops and on buses, causing overcapacity and no physical distancing. This negatively affected the government's efforts to control the spread of COVID-19.

In the governor's regulation that regulated the operation of TransJakarta during the pandemic, the maximum allowed capacity was only 50% during Micro PPKM, Emergency PPKM, Level-4 PPKM. However, in practice, the number of people on the buses often exceeded the capacity. In addition, there was minimal monitoring of this capacity limitation as shown by the Tweet data.

The findings showed a lack of consideration in measuring demand size during peak hours. Hence, there was no optimum arrangement between the number of buses operated during peak hours and the 50% capacity reduction, falling short in the bus frequency and causing longer waiting times

during peak hours. While the total ridership during PPKM was reduced to 50%, the peak hour demand was larger. Thus, the demand reduction was not automatically translated into a 50% bus capacity reduction, bus frequency services and a reduction of the number of buses operated. The demand needs to be analyzed to appropriately offset the implications of the 50% capacity restriction by maintaining a proper bus frequency and headway arrangement considerable enough to avoid crowding. Using Tweet data could allow TransJakarta providers to generate reliable information, hence, implementing a reliable policy for better public transport services during a pandemic.

The last prioritized variable was staff availability in buses and at bus stops. Based on the content analysis results, it was found that staff were insufficiently decisive in reprimanding if there were violations of the health protocol. In addition, staff were perceived as not good at serving users, e.g., using their cellphone during work and talking rudely to users. Consequently, people were concerned about the unavailability of staff who stood by in busses or at bus stops.

These four prioritized variables aligned with the TransJakarta user satisfaction survey conducted in 2020. Weak monitoring in implementing bus services related to these four variables led to poor management in controlling the spread of COVID-19 in public transport. The results were not aligned with the objectives of the regulations implemented by PT Transport Jakarta.

The results of the sentiment analysis of Tweet data provided a meaningful analysis for policy evaluation, such as government directives on the use of public transport and its service standards during the pandemic. The results highlighted areas of weak or failed policies in terms of monitoring the regulations by PT Transport Jakarta. In the future, information from Tweets may contribute to better implementation of health protocols to prevent the spread of COVID-19 or another virus, hence, increasing the resilience of public transportation systems during the pandemic.

Conclusion

This paper evaluated TransJakarta Busway's service in support of controlling the pandemic using Twitter sentiment analysis. Data mining from Twitter was conducted, providing the main source of data, supported by secondary data from a literature review and an institutional survey from PT Transportasi Jakarta to enrich the understanding of the context. Based on the identification of COVID-19's impacts on TransJakarta's service, it was proven that the COVID-19 pandemic significantly influenced TransJakarta's service operations. This can be seen from the drastic decrease in users, the increase in route closures, and the small number of operating buses compared to pre-COVID-19 pandemic. In addition, COVID-19 also affected the behavior of users, as seen by the reduction of travel frequency and duration using TransJakarta. This phenomenon was caused by the government's implementation of a mobility restriction policy to reduce the spread of COVID-19.

Furthermore, from the sentiment analysis results, it can be concluded that during the months of observation (May to August 2021), there were 1886 negative sentiment Tweets, 2,006 neutral sentiment Tweets, and only 180 positive sentiment Tweets. These Tweets were grouped into 17 variables. The highest number of Tweets was in May 2021, with as many as 1,570 Tweets, because during this month, the COVID-19 situation in DKI Jakarta was not severe as in the following months. The most frequently commented variables on Twitter was bus operational time, followed by bus service frequency, physical distancing implementation, capacity restrictions, staff availability, and cashless transaction implementation. The bus service frequency variable had the most negative sentiment Tweets, with 32% of the total negative sentiment Tweets. For

the neutral sentiment, the bus operational time variable had the most Tweets (77%) since many people asked about TransJakarta operating hours due to policies that kept changing during the COVID-19 pandemic to adjust to fluctuations in COVID-19 cases in DKI Jakarta.

In identifying the priority areas of TransJakarta's service in controlling the COVID-19 transmissions, four variables were found to be crucial to improvement: bus service frequency, physical distancing implementation, capacity restrictions, and staff availability. The main topics discussed for the bus service frequency variable were long bus arrival times, small bus fleets, and long headways, resulting in long queues and passengers crowding at bus stops, especially during rush hours. The accumulation of passengers made COVID-19 more challenging to control because of the difficulty in maintaining a safe distance between individuals, which should be the key to preventing the spread of COVID-19. Low bus frequency during peak hours impacted the implementation of physical distancing. Hence, the implementation of the variable of capacity restrictions, questioning the absence of capacity restrictions both on buses and at bus stops. Finally, it was revealed that many officers did not perform well in monitoring the implementation of the health protocols on buses and at TransJakarta stops, exacerbating the weakness of the other three variables. Weak implementation and monitoring eventually made the government's efforts to control the spread of COVID-19 in public transport more difficult.

This research proposed that using Twitter data could replace conventional data collection methods such as observation and user interviews. Beneficial information could be captured relatively easily and at a low cost. As such, it formed an evaluation of policy implementation to create more resilient public transport during a pandemic.

The results from the Twitter data represent the four priority areas that need to be improved by PT Transportasi Jakarta to control the spread of COVID-19 based on Twitter sentiment analysis. However, Twitter was only used by 46.7% of TransJakarta users. Further studies regarding TransJakarta service evaluation from various social media platforms is recommended to provide a better overview of how TransJakarta services was perceived. In addition, it may also be necessary to include medical experts' perspectives in the study to examine more deeply the steps that service providers should take to control the spread of COVID-19 or another virus in the future.

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