OVERCROWDED BUSES OPERATING IN DHAKA, BANGLADESH AND THE EFFECTS ON SAFETY, PERFORMANCE, AND COMFORT[1]

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Abstract: Overcrowded buses are a common sight in Dhaka, Bangladesh, swerving between rickshaws and auto-rickshaws, blaring their horn, and shouting out the next spot the bus will stop. The perceived low comfort and safety levels of an overcrowded bus are a deterrent to certain types of riders. Should this type of service be abolished, or rather due to reduction in vehicles plying the roads, be encouraged? Previous research has touched on the crowded nature of buses in developing countries, but a focused study on crowded transit was lacking. By developing a method to evaluate a system which seems disorderly from the outside, the effects crowded conditions have on riders, performance, and safety were studied. With a focus on Dhaka's two primary bus service types, ticketed and local, data was collected over half a year. Despite the negatives crowded buses cause, they operate more efficiently for the volumes they carry. This, however, may not be transferable to other developing countries that do not have constant traffic jams similar to Dhaka, or have different cultural opinions on personal space.

INTRODUCTION

Any resident in Dhaka, Bangladesh will speak of how overcrowded their city streets have become in recent years. As the capital city of the densest country in the world[4], it is not surprising that Dhaka has constant traffic jams. On top of this, Dhaka is growing at the second fastest rate of the twenty most populated metropolises in the world (United Nations 2006). The roads of the city are clogged with vehicles all day long making travel unbearable. Traffic control is handled primarily by the city's police force, and despite their presence there is negligible enforcement of traffic rules. All shapes and sizes of vehicles are part of the traffic: hand-pulled carts, pedal rickshaws, auto-rickshaws, tempos, taxis, private cars, and a wide array of buses (fortunately trucks are restricted from operating in the city except for the nighttime off-peak hours.) Its current transportation infrastructure is overused and cannot carry the future demand; a scene from the city streets is shown in Photo 1.

Transportation of Dhaka

Few people living in the dense urban fabric of Dhaka own automobiles. Private automobiles are owned at a rate of only 33 per 1000 persons, lagging behind all other Asian cities (Barter 2000). Non-motorized transport dominates 80% of movement: over 400,000 rickshaws clog city streets (Hossain and Yordphol 1999) and pedestrians pack the remaining space. Pedestrianism is higher in Dhaka than in any other city of its size, with 60% of residents choosing this mode for convenience or economic reasons. Rickshaws account for 50% of the traffic flow, and are the most popular choice for short distance trips (Andaleeb et al. 2007). Rickshaws only carry travelers so far, however, and restrictions on where they

Photo 1: Different modes interacting in Dhaka's streets.

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[4] Considers only countries which are larger than 1200 square kilometers in size. Overall, there are at most ten small countries or territories which have higher population densities including places such as Monaco, Macau, Hong Kong, Malta, Bahrain, and the Vatican City.

can travel in the city forces many trips to be done by bus. So despite the large amount of non-motorized transport, buses are still carrying over half of Dhaka's travelers although they only account for 10% of all vehicles (STP 2004).

At first glance it would seem that Dhaka has a good system with plenty of low emission vehicles and a high rate of public transport usage. The problems arise due to a lack in the city's infrastructure and transit systems to handle the volumes that currently exist. Ideally in a city with a well functioning transportation system, about 25% of the land usage should be for road transport, however Dhaka sits at around 8%, and two-thirds of these are non-engineered surfaces (Andaleeb et al. 2007). Footpaths are blocked due to sellers of goods, and force pedestrians to walk in the street. The Dhaka Strategic Transportation Plan in 2004 estimated that 40% of the footpaths are blocked illegally, despite a court ruling in 2001 to reduce this activity.

Perhaps Dhaka could handle such a lack of road infrastructure if there were other options for travelers, but it lacks a mass transit system as well as an organized bus system, the only city of its size worldwide to be in such a position (Andaleeb et al. 2007). While other Asian cities have high rail usage amongst their public transit options, Dhaka's is negligible, and without a rail system to supplement the volume on the roads, travelers going longer distances must board the wide array of privately owned buses that operate on the city streets (Barter 2000). Dhaka's number of buses are not set to comfortably handle the number of passengers that desire to use their services. Haque and Hossain describe in their report that Colombo, Sri Lanka has 7600 buses for 4.6 million people, while Dhaka is desperately lacking with only 2000 for 10 million. To meet the fast growth demands the number of buses may have to be up to seven times larger within fifteen years. In order to meet the demands of travelers, and to survive financially the private bus companies must overcrowd their buses in order to keep operating. As a result, they are not investing in updating or enlarging their fleets (STP 2004). These factors have all helped to produce a bus system which is overcrowded, and marked by safety, performance, and comfort issues.

BUSES IN DHAKA

Dhaka has several types of buses plying the streets. The 2004 Dhaka STP divides buses into several categories: minibuses (41%), microbuses (30%), large buses (13%), auto tempo/laguna maxi (12%), and staff and school buses (4%). Residents of Dhaka understand the bus system as divided mainly into ticket buses (photo 2), local buses (photo 3), and tempos. The first two of these categories were the subject of this study. Ticket buses have set stoppages on their routes, which can be located by the companies respective ticket counters. Their fares are collected on the curbside from ticket sellers associated with each private company, and have a single conductor on board who checks tickets at the doorway. Almost all of the large buses are ticket buses, and a significant number of the minibuses operate as ticket buses. Local buses have stoppages that are unmarked, but they are fairly consistent with where they stop on their routes, and have on-board fare collection. Local buses can also be boarded and alighted from at any point on the route, at the conductor's discretion. They typically operate with two conductors, one who collect fares and one who stands at the doorway finding potential riders from the side of the road. There are a handful of large buses that operate as local buses, but the vast majority of local buses are minibuses.

Photo 2: Large bus operating as a ticket bus.

Photo 3: Minibus operating as a local bus.

Bus behavior in Dhaka varies significantly depending on the drivers and conductors operating them.

Skipping of stoppages, cutting routes short, and dwelling for very long periods at the curb occur unpredictably, although this is more often observed in local buses. These annoyances to travelers can vary between off-peak and on-peak periods, and it is for these reasons that many travelers choose to avoid riding buses (Zahir et al. 2000). Common complaints from bus riders in Dhaka include long waits for buses, unexpected delays while the bus is moving, lack of comfort, and long walks from origins and destinations to the bus stops (Hoque et al. 2005).

Overcrowding on Buses

Photo 4: Passengers on an overcrowded ticket bus hang out the door, grasping the doorframe to stay on.

The buses of Dhaka are bursting at their seams with passengers, with travelers filling every available space in the aisles, and forced to hang out the door frames in the most extreme conditions, as seen in Photo 4. This not only is a comfort issue for many passengers but also affects the safety level at which the buses operate. For many passengers the link between crowding and safety is strong, with some feeling not only less comfortable but also less safe amongst their co-passengers during crowded conditions (Cleland and Thompson 2000). In a report about the ergonomics of bus riding, Kogi describes how passengers are able to handle the crowded conditions, but tolerance for such conditions decrease after a certain threshold. As either the number of passengers and the length of time for being crowded independently increase, passengers reach a point where they are perplexingly discomforted (1979). In Dhaka this can be a serious issue because traffic jams are prevalent. As the bus sits in traffic, the amount of passengers walking past and boarding the bus increases, while concurrently passengers are enduring long waits under these increasingly crowded conditions.

How the operations of buses change when they are crowded is not a greatly understood topic. Most of the studies focus on the dwell times of the bus, the amount of time it waits at the curb. The lack of research in this area is due to the amount of time needed to gather this type of data, requiring a lot of man-hours at high cost, only to produce a small sample size. It is generally accepted that the time for alighting is less than that for boarding, but figures on how much this changes per passenger varies significantly between studies (Dueker et. al. 2004). As well, it is shown that the time the bus spends at the curb is linearly related between the number of boarders and alighters (Vijaykumar and Jacobs 1990), but how it relates to the bus' current loading is not considered. Many studies have considered the volumes at which buses' travel at and how it relates to capacity, but do not relate them to dwell time (Vijaykumar and Jacobs 1990, Perk et al. 2001, Fernandez and Tyler 2005).

METHOD

In Dhaka's bus system the wide array of bus types, high tolerances for crowded conditions, and reactionary behaviors for operation by the conductors and drivers create an interesting environment to observe the effects of crowding on bus operations. The structure of the study was aimed to target certain variations in bus types and examine the way they performed when overcrowded. As the goal was to capture what happens at individual stops, as opposed to the route as a whole, it was decided that a variety of buses needed to be captured in the data collection. Of primary importance was the differences in how the two main bus types, ticket and local, operate, followed by the size and location of doors on the vehicles. A stratified sample of buses was chosen for riding, ensuring that data would be collected on different door number and arrangements on both ticket and local buses. Ultimately, ticket buses would have 90 trips collected and local buses 54 (ticket buses have a wider variety of door arrangements.) Each of the routes were ridden three times in each direction. Routes were chosen from all parts of the city, and when possible, a route which started and ended within city limits. All buses would be ridden only within the city limits. For this study it meant that buses were only ridden until Abdullahpur in the northeast, until Jatrabari in the southeast, and Gabtoli in the northwest.

All routes were ridden from origin to destination, or the geographical limits of the study. The researcher sat on the door side of the bus, in order to observe what happens at the curb. A voice recorder was used to count each board and alight, the arrival and departure time of the bus from the stop, and the point at which the bus rejoined the traffic stream. Passengers who boarded and alighted in between stops were noted as early or late in reference to the previous or next stop. To distinguish these movements which occur quite frequently, especially in the case of local buses, criteria were established. The number of people standing before the first row of seats and immediately in front of the middle or back doors was recorded as a measure of a bus' crowding levels. The number of people who remained at the bus stop who could not board and the number of passengers with some part of their body outside the doorframe were also recorded.

Responding to the concerns raised by Dueker et. al., it was attempted to create as large a sample size as possible while still maintaining on-board observing. To gather a complete and significant data set, on-board data collection was coupled with curb-side data collection. At several bus stops in the city the arrival and departure time of each bus from the stop was recorded, as well as the measurements of how crowded the bus was (before the front row and in front of any middle or back door.) Data was collected three times at each location, both the morning and evening peak periods and a midday measurement. The bus stops were chosen to capture the most crowded points of buses' routes, in line with the practice performed described by Perk et al. (2001).

A final goal of this study was to understand the internal dynamics of a bus under crowded conditions. Although attempts were made to qualify this part of the study, it proved too difficult to measure in the time frame of the study and the resources available. Thus a qualitative discussion of the bus operations was reasoned as the best way to communicate how the buses of Dhaka operate.

RESULTS

While the research is ongoing up to this point, early observations are helpful to understand the behavior of the buses and the passengers inside. The differences between ticket buses and local buses are very clear. Local buses almost always get crowded at some point during the route, and it is due to their passenger collection method. A local bus will remain at a stop for several minutes until the conductor feels the bus is sufficiently loaded, which typically means every possible space is filled. Some local buses will leave a stop when a second bus of the same route arrives, but schedules are roughly kept so that the first bus will already be sufficiently crowded by the time of the second bus' arrival. Ticket buses, however, typically wait only for the passengers already waiting for the bus at the stop to board before departing, although there are many occurrences where the bus will wait at the stop for passengers.

The consequences these operational practices have on crowding are that local buses leave almost all their stops with people standing inside, while ticket buses are much more likely to leave with partial loads. As shown in Table 1, only 66 of the 90 ticket buses ridden had riders standing at some point in their route, while all local buses have been crowded at some point during their route.

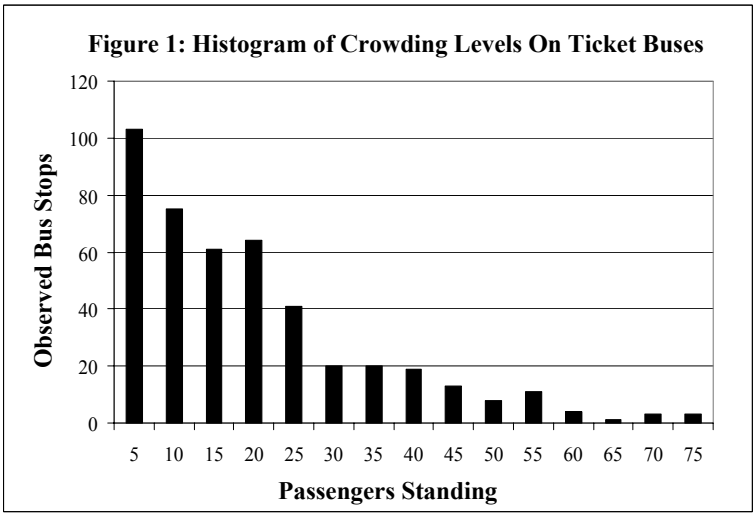
Table 1: Crowding Levels of Ticket Buses

Number of Passengers Standing	0	1-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79
Observed Buses	24	22	16	13	4	6	3	1	1

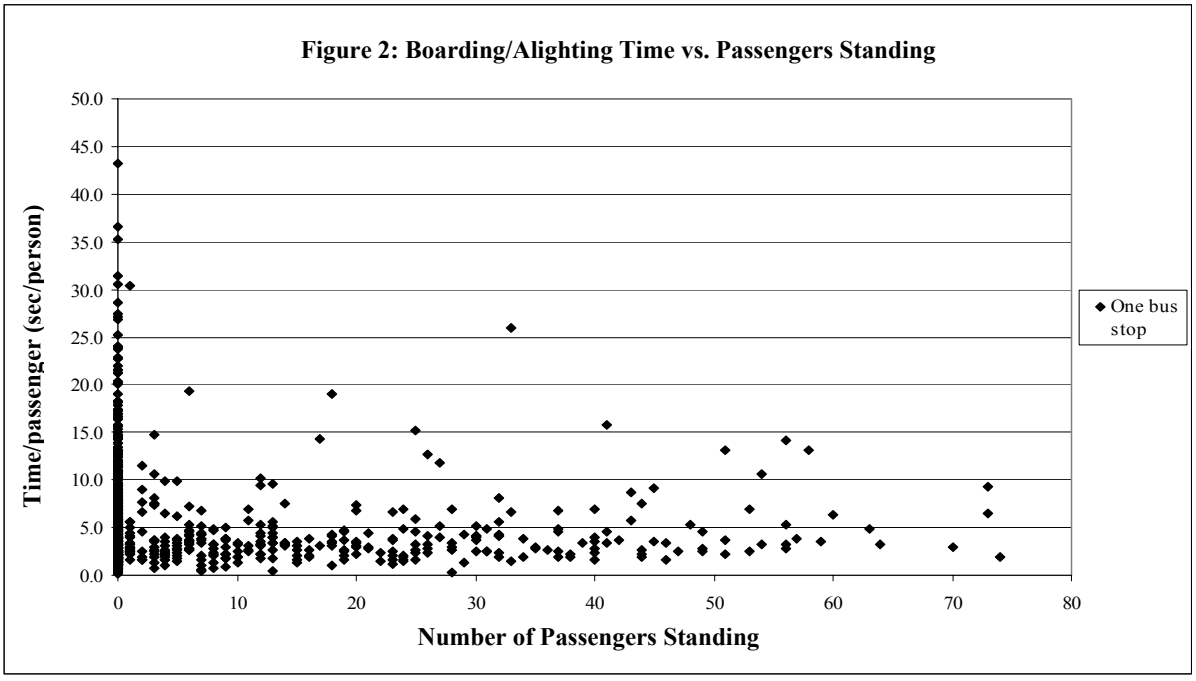
For ticket buses, the middle of the route is generally where this crowding occurs, as these routes are characterized by heavy boarding in the earlier stops, and heavy alighting in the later ones. Over all the ticket buses, only 28 percent of all visited stops actually had passengers standing after departing. There was a mean number of five standing passengers[5] over 1549 observed bus stops, but this value jumps to eighteen if one considers only the 446 stops at which standing actually occurred. All the bus stops at which there were

[5] After data collection is completed, the figure with which the level of crowding will be analyzed will be passengers per square meter of floor space and passengers for a given capacity, to adjust for the different sizes of ticket buses. This will also allow the data collected in Dhaka to be compared to past studies in other cities.

standing passengers are plotted in a histogram in Figure 1, each bar having a bin size of five. Minor crowding is more prevalent, but even with ten standing passengers, a bus can feel crowded. What is an issue is that the middle of the route where crowding occurs more often is usually through congested areas of the city where many buses are stopping. It is at these stops that many passengers are alighting and boarding, and because the bus is at its most crowded at this point, dwell times have a tendency to increase. Additionally, due to the high volume of buses stopping at these congested stops, a bus may be forced to stop several lanes from the curb. Boarders must travel longer distances to get to the bus, adding to dwell time and creating unsafe situations crossing traffic lanes. Although the buses are only crowded for small parts of the route, it is these parts that are most critical that the bus performs efficiently, and crowding inhibits that.



Typically the standing passengers congregate around the doors of the bus. Although this would seem to indicate that there would be extra delay during the stop, due to passengers needing to push through large groups of people to alight and board, it is not as severe as it could be. Passengers have adapted to the crowds and know to get to the door before the bus reaches the stop. Figure 2 displays that as a result of passenger adaptation, there is very little change in the rate at which passengers board and alight. Variation in the rate when the bus is crowded can many times be contributed to the bus being stuck in a jam of other buses and



passenger/conductor arguments. That ticket buses also wait to fill up their bus with passengers can be seen by the high rates for the buses without any passengers standing. Otherwise, the typical rate for Dhaka ticket buses is between 2.0-6.0 seconds per passenger.

The dynamics inside the bus that allow such consistency even at the most crowded levels involve a bit of pushing and aggressiveness. Photo 5 shows a bus that has every standing space occupied, although still not at the maximum load, that forces passengers to have to shove one another to board and alight. Any sitting passenger who stands to go to the door to alight is instantly replaced by an eager standing passenger.

Alighting passengers force their way through the crowd, and others shift towards the back to allow room at the front. Thus the majority of the passengers who desire to alight from the bus are already at the door by the time the bus arrives at the stop, and this cuts down on dwell time. This leads to boarding passengers having space to board on the bus directly by the door, with limited pushing involved, helping to reduce dwell time. The conductor of the bus is many times an integral part of maintaining the best performance, yelling to passengers to move back if their stop is farther along the route.

Photo 5: Passengers on a crowded ticket bus have to force their way through others to get to the door.

DISCUSSION AND CONCLUSIONS

Prior to the start of data collection, it was hypothesized that crowding on buses would cause delay in dwell times, and this delay would increase in a non-linear fashion. It was reasoned out that each additional passenger on the bus has to push through increasingly more people to get off or on the bus. It was reasonably assumed that each additional passenger would take a bit longer to board the bus than the passenger before. This would result in a non-linear increase in dwell times. The results, from the ticket bus portion of the data collection, do not show what was initially hypothesized, and it is clear from initial results that the local buses will only reinforce this. Due to the passengers' adaptation to the crowded conditions, the dwell times were inadvertently reduced from what would exist if all riders did not adjust. Before the bus has even reached a stop, most of the passengers who want to alight have already stood up from their seats and wait by the door. If the bus is extremely crowded, passengers begin making their path to the door extra early, knowing they have a large number of other passengers to squeeze through. If a bus spends more time at the bus stop it is generally not because the bus is crowded or not.

It is observed that the business model steering privately owned buses operating in Dhaka, both ticket and local systems, do not show signs of changing or reform. It is not hard to imagine that more could be done to increase comfort and perceived safety for passengers, but the existing system seems to operate efficiently and yield profit margins that allow continued similar service. In the study period, there were bus companies that ceased operations due to lack of profits, and new routes were formed to meet new demands. In fact, many of the ticket bus companies have only been operating for less than four years. Regardless of what is plying the roads, passengers have become accustomed to crowded buses and preferred methods for quickly boarding and alighting buses have emerged over time. Barring pressure from the government or new infrastructure, buses will likely remain crowded.

One issue that still remains is if there is any reason to encourage operators to reduce crowding on their buses. Due to the extreme levels of congestion in the streets of the city, buses cannot keep consistent schedules. This means that passengers will prefer to board a crowded bus, even at the risk of their personal safety, rather than wait an unknown length of time for the next bus to start. This was particularly evident when headways between buses of the same company shrunk due to the unpredictability of traffic flows. A crowded bus would arrive at a stop, followed quickly after by a non-crowded bus of the same company. Most boarders fought to squeeze into the few spots on the first bus, rather then take the open spots on the bus which would leave a minute or two later. The operators do not appear to discourage these large loads. Any countermeasures against crowding, such as bypassing stops when crowded, were left mainly to the conductor's discretion. One of the options companies take is to operate similar to a jitney system, filling up with passengers when they are there, and if they are not, hoping for the next stop. Unless Dhaka's traffic situation improves, there is little to motivate operators to reduce crowding and move to more consistent scheduling and operations.

Although many passengers may prefer the additional personal space that a non-crowded bus offers, it would mean increasing the number of buses on the road. This is something that Dhaka, its operators, and the environment cannot afford. Firstly, an increased number of vehicles on the road would only jam up Dhaka's already crowded roads more. Secondly, the operators would have to spend more money on increasing their

fleet and then running the buses under already high fuel costs, expenses they are unlikely to take on given the current low level of investment in the fleets. Lastly, more buses on the road is detrimental to the air quality of a city which only recently has seen improvements in this area. Until Dhaka's traffic situation can be improved through a planned mass transit system, whether it be rail or bus rapid transit, there is no motivation to make efforts to reduce the loads Dhaka's buses carry.

The results of this study, when complete, will be helpful to the planning purposes of Dhaka. The applicability to other developing nations' cities needs to be considered carefully. Different cultures have different levels of comfort, and the immense packing in the buses that Dhaka's residents endure may not be tolerated by residents of other cities. As well, the manner in which Dhaka's buses operate are likely different from other approaches, and one which has a large organized system would likely see benefits from a reduction in crowding. The crowded bus system of Dhaka, however, is currently operating advantageously within the constraints of the present infrastructure.

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