Passenger Reactions to Transit Safety Measures

To be published as:

Wallace, Richard R., Daniel A. Rodriguez, Christopher White, and Jonathan Levine. (1999) Who Noticed, Who cares? Passenger Reactions to Transit Safety Measures. Forthcoming, *Transportation Research Record.*

Abstract

Safety and security are important considerations for the transit operator, but few empirical studies exist that measure the effectiveness of measures taken to improve transit safety on either actual crime (or other incident) data or transit passengers' perceived safety. The current study focuses on the links between transit safety measures implemented in the Ann Arbor, Michigan region, the visibility of these improvements to transit passengers, and perceived levels of safety. The findings indicate that the characteristics of passengers' riding patterns, and whether or not a safety measure was noticed all played some role in determining perceived safety. Additionally, ridership patterns and personal characteristics also affected whether or not passengers noticed safety enhancements. Of the measures undertaken, increased police presence and increased lighting proved most effective in increasing perceived levels of safety, and these were also the most visible. Safety measures also had their largest positive effect on perceptions in association with those transit places and situations perceived as least safe. In a similar vein, while women felt less safe overall than men, they were more likely to notice safety enhancements and to feel safer as a result. Future efforts to build on this research should incorporate actual crime statistics, thereby extending the models discussed and providing a comprehensive view of the relationships between crime, safety enhancements, and passenger perceptions.

Overview of AATA's Advanced Operating System

In 1997, the Ann Arbor (Michigan) Transportation Authority began deploying advanced public transportation systems (APTS) technologies in its fixed route and paratransit operations. The project's concept is the integration of a range of such technologies into a comprehensive system, termed the "Advanced Operating System" (AOS) to "smart buses", "smart travelers," and a "smart operation center" to benefit from timely and coordinated information on critical aspects of transit operation and maintenance. The prime contractor for the project was Rockwell, and providers of other integrated subsystems included: Digital Recorders Research of Triangle Park, North Carolina; Trapeze Software of Mississauga, Ontario; Prima Facie of King of Prussia, Pennsylvania; REI of Omaha, Nebraska; Red Pines Instruments of Denbigh, Ontario; and Multisystems, Inc. Cambridge, Massachusetts. Evaluator for the project was a team from the Urban and Regional Planning Program of the College of Architecture and Urban Planning, University of Michigan.

"The Smart Bus"

Central to the system is the deployment of automatic vehicle location (AVL) technology in order to provide continuous real time data on the location of transit vehicles. Each bus determines its location using global positioning satellite (GPS) technology; differential corrections are broadcast to the vehicles so they can calculate their locations within one or two meters. A Mobile Data Terminal (MDT) in each vehicle stores complete route schedules on an insertable memory card. The GPS system provides accurate time to the vehicles. Buses compare scheduled times and locations with actual locations to determine their schedule adherence. If a bus determines that it is running late, the driver is advised, and if necessary, the onboard computer notifies the Operation Center. The AVL also triggers an outside destination announcement and the internal next-stop signs and announcement. It also integrates location data with fare collection, electronic controlled engine data and ultimately, automated passenger counters,

The AATA network makes use of extensive timed transfers at four major transfer points. When a bus is running behind schedule, AOS enables digital bus-to-bus communications to improve the transfer between buses; the driver of the first bus can send a digital request (that includes the bus' location) to hold the second bus to ensure that a passenger will not miss a desired transfer.

Video surveillance is provided on board vehicles for security, as well as to help resolve any claims that may arise.

On the paratransit side, drivers receive their entire schedules and mark their arrival and departure times with date, time and location information as well as all the features above.

"The Smart Operation Center"

The AATA Operation Center collects and acts upon information provided by the transit vehicle and drivers. Each AATA bus has an 800 MHZ radio and onboard computer. The system minimizes voice transmissions by providing data messages that summarize vehicle status, operating condition, and location. Out-of-tolerance engine conditions such as oil pressure and temperature are reported in real time to the onboard computer, the Operations Center and the Maintenance Department.

Through the use of real time displays of vehicle location and schedule adherence reporting, dispatchers working at the Operation Center can manage the system and assist drivers by inserting overload vehicles in the system or recommending re-routing options. All changes to the route and schedule database are noted and automatically updated.

Onboard the vehicle, the driver has an onboard emergency system. When encountering a life-threatening situation, the driver covertly alerts the dispatcher, who immediately notes the vehicle's location on the system's center map and dials the appropriate agency. The system also allows the dispatcher to open up a central public address system inside the vehicle to monitor the situation. The system also supports responsive reporting of routine, non-life-threatening emergencies, such as passenger inconvenience.

For paratransit vehicles, reservations, scheduling, flexible integration with fixed-route, and after-trip information utilize Trapeze software. All of these elements are based on real-time information generated with the Rockwell TransitMasterTM software.

"The Smart Traveler"

The "smart travler" a person informed about his or her transportation options, as well as about current conditions relative to transit use. Inside the bus, next stop announcements, date, time and route are given to passengers utilizing the onboard public address system and a two line LED display. The driver also has the ability to trigger timed and periodic announcements for special events that can be made to support the system. Outside the bus, the current route information is announced to waiting passengers, and the destination signs are changed based upon the location. Kiosks will 7provide real-time bus location information at selected locations; ultimately this information will be provided to travelers at their home or workplace via telephone, cable television or internet.

Safety of Transit Systems

An old adage holds that transit must be reliable, safe, and clean to attract riders. Of these three concerns, the first receives enormous attention from both transit professionals and transit researchers, while the latter two are more rarely the topic of transportation research. From the little research that has been conducted on transit safety and security, however, we know that travelers often perceive transit as less safe than other modes, especially the automobile, hurting transit's mode share. Ball and Mierzejewski (*1*), for example, found that 59.9 percent of respondents to their survey thought that the auto was the safest mode of travel, while only 16.1 percent thought that the bus was the safest mode. Other studies (*2*,*3*,*4*), too, have concluded that safety and security are important factors in determining mode choice, although the magnitude of the effects varied widely. Such studies, while useful at a highly aggregated level, offer few insights into effective ways of improving either safety or passenger perceptions of safety.

As discussed by Benjamin, et al. (*5*), perception and reality are not always the same. Some past research has concentrated on measures to improve "true" and perceived levels of transit safety. Most safety and security improvement measures can be categorized as one of the following types: patrol and security, design actions, media and information campaigns, and technological (*6*). Two recent surveys of transit agencies found that uniformed patrolling strategies were considered subjectively to be the most effective strategy to improve security, though the perspectives of passengers were not included in these studies (*7*,*8*). Design actions for higher safety include better lighting and visibility, fencing, and signage among others. Pearlstein and Wachs argue that in order to increase safety perceptions of riders, the transit environment around stations needs higher attention by transport planners (*9*). Levine and Wachs present a group of physical design measures for creating a higher sense of safety (*10*). In a study from Greensboro, Benjamin found little actual crime and hence argued in favor of a public relations campaign in order to bring people's perceptions closer to reality (*5*).

There is no agreement about the use of technology as an effective safety measure. Based on the Greensboro study, Ingalls et al. (*11*) conclude that transit agencies should focus greater attention on the soft approach to transit safety issues rather than the high-tech approaches. A recent, comprehensive survey of transit agencies revealed that more than half of those surveyed report use of technology to prevent or deter crime, but made no mention of technology's effectiveness (*7*). Using crime statistics Shen et al. (*8*) found that closed circuit television surveillance was the most effective way to combat different types of transit crimes . Despite these reports, there seems to be a paucity of information regarding the effectiveness of security measures on rider's perceptions. As a result, Needle and Cobb have called for "an ambitious program to scientifically evaluate core [safety] strategies employed by transit agencies" (*7*).

Faced with safety concerns rooted both in perceptions of safety and (potentially) objective measures of safety and security, transit agencies have a vested interest in both improving the overall safety and security of their systems and learning how measures nominally implemented to improve safety and security actually affect passengers' feelings of safety. Through analysis of safety and survey data from Ann Arbor, Michigan, this study focuses on passenger reactions to measures taken by the Ann Arbor Transportation Authority (AATA) to improve safety on-board its buses and at its two transit centers. The centers are especially critical points for improving safety, because AATA operates a predominantly radial, fixed-route system with its central node in downtown Ann Arbor at the Blake Transit Center (BTC) and a secondary center in downtown Ypsilanti at the Ypsilanti Transit Center (YTC).

Safety and Security Measures in the Ann Arbor Region

Improving safety and security was an important consideration in the design of the AATA's Advanced Operating System (AOS). Other elements of the AOS, to be evaluated in separate studies, include automatic vehicle location, automatic passenger counters, and mobile data terminals.

Even prior to the introduction of the AOS, the AATA had a variety of programs and equipment in place to enhance safety and security including:

- Comprehensive new driver and refresher training in all aspects of safety and security
- Formal review and evaluation of accidents and incidents
- Security cameras at transit centers. At the BTC in downtown Ann Arbor, the cameras were included when the building was constructed in 1987. At the YTC, in downtown Ypsilanti, a camera was included when the building was constructed in 1991, and two additional cameras were added in the spring of 1998.
- Security lighting at both transit centers. Lighting was enhanced at the YTC in 1998.
- Police mini-station at the BTC. Prior to 1993, the AATA used private security at the BTC. In 1993 the AATA began contracting with the Ann Arbor Police to locate a mini-station inside the BTC and provide police officers to patrol the area and ride buses, as necessary.
- Eastern Michigan University (EMU) security station at the YTC. Since the opening of the YTC, security has been provided by the EMU Police Department using student security officers.

This program notwithstanding, AATA's safety statistics are quite excellent, leaving less room for improvement than might be the case in some larger cities. AATA's rate of vehicle collisions, as well as non-collision incidents, has consistently been below the industry average as reported in the National Transit Database. In 1997, the AATA reported a total of 16 collisions in 2,541,007 total actual vehicle miles, and five non-collision injuries. No incidents of violent crime or property crime were reported, while two arrests were reported for assault and one for fare evasion.

In addition to the safety and security categories in the National Transit Database, the AATA maintains a written incident report for a wide variety of occurrences. Essentially, AATA drivers and other personnel are trained to prepare a written incident report for any occurrence that could have resulted in an injury, as well as for all incidents in which any kind of dispute or altercation occurs. Personnel are instructed that "when in doubt, prepare an incident report."

Safety and security can be evaluated by the frequency and severity of occurrences, but the perception of safety and security by riders, employees, and the general public is also a very important component. Perceptions, however, may or may not be directly related to the actual frequency of occurrences. One highly publicized crime may significantly affect perception. The cleanliness of a transit center, too, may affect patrons' feelings of security.

Method

The survey data that form the backbone of this study derive from a survey of AATA's fixed-route bus passengers conducted in the spring of 1998. Where useful, results from a previous survey of AATA passengers (conducted in the spring of 1997) also are presented. For both survey efforts, the sampling design consisted of selecting a stratified (by route and time of day) random sample of AATA bus routes in each year, except that park-and-ride shuttles serving Eastern Michigan University were excluded, as were weekend trips. Thus, each survey effort produced a representative picture of the demographics, attitudes, opinions, and perceptions of AATA weekday patrons at the time of the survey. Additionally, few changes were made to AATA routes during this period, meaning that the routes available for selection in each year were nearly identical.

Because many elements of the AOS were added in between the two survey periods, during which time the AOS received ample local media attention, we might expect that differences in passenger perceptions of safety and security are due to increased awareness of the safety and security elements of the AOS. Nonetheless, as described above, AATA made several safety enhancements prior to either survey effort. Thus, for many indicators we might well expect no significant perceptual differences between surveys. Indeed, this often proved to be the case. Therefore, for the most part the results presented below focus on the most recent survey, that conducted in spring 1998. Both surveys are used, however, when significant perceptual differences between surveys were found.

Results and Discussion

Besides the effects of actual incidents and measures to improve safety, perceptions of safety and security can be expected to vary by other factors, including some associated with the riders, such as their age, sex, and the like. Maxfield, for example, reports that women who felt more insecure about the transit system exhibited obvious reductions in night-time activity (cited in *6*). This avoidance behavior is further confirmed by a Greater London Council survey that found that 63% of women felt unsafe using the bus alone at night (*6*).

Based on the 1998 survey (results similar for 1997), 56 percent of respondents are female, just less than one-quarter (23 percent) are college students, about half are employed at least part-time, and just less than ten percent are retired. Respondent incomes varied quite a bit, but 35.5 percent reported a household income of less than $15,000 per year, while another 30.0 percent reported a household income between $15,000 and $30,000 per year; at the other extreme, 5.7 percent reported a household income greater than $75,000 (see Table 1). Respondent ages ran the gamut of young to old, with a full 25.0 percent between 18 and 25, and another 20.7 percent between 26 and 35 (see Table 2).

Table 1. Respondent Age Groups (n=1,064)

Age Group	*Percentage*
12 or less years	0.3
13 to 17	12.3
18 to 25	25.3
26 to 35	20.7
36 to 45	17.9
46 to 55	10.9
56 to 65	5.6
66 to 75	4.3
76 and above	2.7

Table 2. Respondent Household Income (n=830)

Income Category	*Percentage*
Less than $15,000	35.5
$15,000 to $29,999	30.0
$30,000 to $44,999	16.0
$45,000 to $59,999	8.3
$60,000 to $74,999	4.5
$75,000 and above	5.7

Ridership patterns, too, may affect feelings of safety and security. Benjamin, et al. (*5*), for example, found that perceptions differed between users of the bus system and non-users, with the latter perceiving significantly lower levels of safety. Given that the current study focuses only on riders, we might hypothesize that more frequent riders will perceive relatively higher levels of safety. We also want to examine the extent to which the respondent is dependent on transit, as those lacking other transportation options may not necessarily be able to decrease their riding frequency due to perceived lack of safety.

Examining the 1998 survey results, we find that nearly 75 (74.5) percent of respondents reported riding an AATA bus on at least three days in the previous week, and nearly half (47 percent) reported riding at least five days (n=1,255). Overall, 26.7 percent of respondents reported having no other travel options but AATA for the trip on which they were surveyed (driving, getting a ride, walking, and biking were offered as options), and frequency of ridership does vary significantly by whether or not the respondent reported having other options (χ^2=12.4; p=0.014; n=1,228). On the other hand, more than forty percent of those with other options for the surveyed trip rode the bus on at least five days in the previous week (compared to more than 50 percent for those without options). Similar results are obtained even if driving is treated as the only alternative to transit. Viewed as a whole, these results suggest the existence of a solid core of frequent riders, many of whom select AATA over other available modes, including the automobile. The direct and indirect effects of ridership patterns on perceived safety are discussed below.

Overall Safety and Security Ratings

Of those survey items dealing explicitly with safety and security issues, three distinct types of questions were used. First, respondents were asked to rate six items in terms of safety from “very safe” (coded 5) to “very unsafe” (coded 1). All six of these items dealt with AATA places and activities, such as riding a bus or waiting at the Blake Transit Center. Second, respondents were asked if they had noticed (yes or no) five types of safety measures taken by AATA (four specific to changes at the two transit centers and one referring to the on-board video cameras). Third, respondents were asked to rate how the four changes at the centers affected their feelings of safety and security there (“much more safe,” coded 5, to “much less safe,” coded 1).

Beginning with those questions addressing places and activities, on average respondents rated all items toward the safe end of the spectrum, with riding the bus rated the safest of the offered choices and waiting at the Ypsilanti Transit Center the least safe (see Table 3; all items significantly different from one another at p=0.05 or better via paired samples t-test). Riding the bus after dark, however, achieved a relatively low average rating--second worst of all. Differences between the two transit centers likely are due to two factors: (1) absence of police at YTC (though student security personnel are present), and (2) the general perception that Ypsilanti is less safe than is Ann Arbor, a reflection of the former’s higher crime rates.

Table 3: Respondent Ratings of AATA Safety and Security

Item	*Mean Safety Rating*	*Sample Size*
Waiting at usual stop	4.44	1233
Riding an AATA bus	4.49	1228
Waiting at the Blake Transit Center	4.13	1065
Waiting at the Ypsilanti Transit Center	3.61	732
Riding the bus after dark	3.73	946
Walking to and from usual stop	4.30	1193

Of the five specific measures taken by AATA to enhance safety addressed in this study, the on-board video cameras proved to be the most noticeable to the riders (70.0 percent noticed). The four measures taken at the transit centers varied considerable in relative visibility, with transit center video cameras most noticed (63 percent of respondents), followed by more police (51 percent), increased lighting (42 percent), and emergency phones (28 percent). Thus, video cameras are the most visible safety measure; even when considering only safety measures taken at the transit centers, video proved more visible than increased police presence. Finally, emergency phones, the most passive measures were not noticed by nearly 75 percent of respondents, casting potential doubt on their utility.

Finally, comes the issue of which safety measures best affect feelings of safety at the transit centers. Our results from 1998 show that having more police present has the largest effect on passenger feelings of safety, though barely distinguishable (p=0.080 for paired t-test) from increased lighting (see Table 4). Emergency phones and video cameras have a smaller impact (p<0.010 compared to increased lighting or police) on feelings, though still to the positive side (and statistically indistinguishable from one another).

Table 4. Influence of Safety Measures on Feelings of Safety at Transit Centers

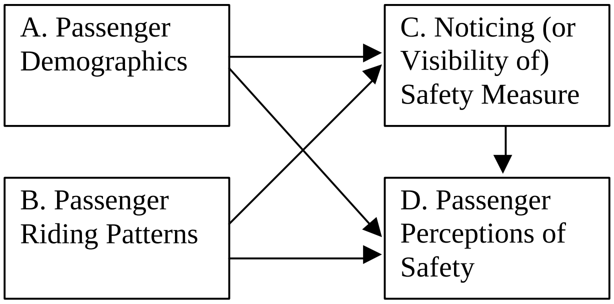
Safety Measure	*1998 Safety Effect*	*Sample Size*	*1997 Safety Estimate*	*Sample Size*
Emergency phones	4.20	978	4.28	906
More police around	4.35	1058	4.06	908
Video cameras	4.18	1049	4.02	904
Increased lighting	4.30	1006	4.33	892

Somewhat at odds with these findings in 1998, when asked in 1997 to indicate how these four approaches, if implemented, would influence their feelings of safety, respondents indicated that increased lighting and emergency phones would do the most to make them feel more safe, with police and video scoring much lower. Perhaps, the much higher visibility of the police and lower visibility of the emergency phones is responsible for this turnaround after implementation. This hypothesis will be tested below.

Linking Safety Measures, Their Visibility, and Perceived Safety

To test the hypotheses raised above, we turn to the literature findings discussed above and the results discussed so far. Basically, we want to test the relative effects of safety enhancement measures on passenger perceptions of safety, as well as the importance of having improvements that passengers actually notice. Speaking statistically, we want to examine how demographic factors and riding patterns effect how well passengers notice safety improvements and, in turn, how these three factors affect passengers' feelings of safety (see Figure 1). Additionally, we would like to be able to determine the relative importance of these three factors on feelings.

Figure 1. Model of Passenger Perceptions of Transit Safety to Be Tested



One appropriate tool for testing such a model statistically is through the use of path analysis, consisting of a series of multiple regressions (one for each dependent variable, shown in Figure 1 by a box with an incoming arrow). Having data concerning five different measures to affect safety, we can test the utility of the model for each safety measure and also judge the overall utility of the model. As a complication, however, and a departure from traditional path analysis, the visibility variable is dichotomous (noticed or not noticed) for each safety measure, suggesting the need for logistic regression to predict whether or not a measure was noticed. For predicting the perception variables, multivariate linear regression will be used. Because we are concerned with the significance and sign (positive of negative) of the hypothesized relationships, rather than with overall prediction, estimated constants are not reported for any of the models reported below.

Proceeding with the first step in the path analysis—the arrows leading into Box C from boxes A and B in Figure 1--we have five models to test, one for each safety measure that may or may not have been noticed by respondents. As measures of a respondent's riding pattern, we have two variables: (1) number of days rode in the past week, and (2) whether or not the passenger had other transportation options available for the surveyed trip (0=had at least one option; 1 = had no other options). Age (years), household income (dollars), and sex (0 = Male; 1 = Female) are available as demographic predictors. Table 5 summarizes the results of these models by showing the utility of the independent (the riding and demographic) variables in predicting the visibility of each safety measure, along with statistics judging the overall goodness of the model.

Table 5. Models Predicting Visibility of Safety Measures

	Visibility (Dependent) Variables				
Independent Variables	Emergency Phones	More Police	Video Cameras at Centers	Increased Lighting	Video Cameras on Bus
Lack Options	-0.104	-0.168	-0.126	-0.043	-0.169
Days Rode	-0.043	0.200**	0.161**	0.059	0.223**
Sex	0.149	-0.144	-0.060	0.331*	-0.032
Age	0.012*	0.008	-0.013*	0.005	-0.011
Income	-5.9×10^{-6}	-1.1×10^{-5}**	-9.9×10^{-6}**	-8.7×10^{-6}*	$2.3 \mathrm{X} 10^{-6}$
Model Significance	0.134	0.000	0.000	0.023	0.000
Cox and Snell R^2	0.012	0.059	0.039	0.018	0.045
Sample Size	720	729	730	725	709
-2 Log Likelihood	855.4	966.5	922.5	974.9	821.7

*Significant at $p<0.05$.

**Significant at $P<0.01$.

The analysis reveals that all visibility measures, save for that associated with emergency phones, are significantly (but weakly) predicted by the model. The number of days ridden in the past week and household income emerged as the most consistently significant predictors, with each significant in three out of five models. More frequent ridership was associated with a greater probability (16 to 23 percent greater) of noticing increased police, transit center video cameras, and bus video cameras. Higher income, conversely, was associated with a lower probability (by about 10 percent for each $10,000 of income) of noticing increased police, increased lighting, and transit center video cameras. Age also proved to be a significant predictor in two models, with each ten year increase in age associated with a 12 to 13 percent lower probability of noticing the emergency phones and the transit center video cameras. Surprisingly, sex proved a significant predictor only for noticing increased lighting, with women 33 percent more likely to have noticed. Lacking alternative transportation options was not a significant predictor in any of the models.

The next step in the analysis (the links from boxes A, B, and C into Box D) involves employing multivariate regression to predict passenger perceptions of safety based on respondent demographic characteristics, riding patterns, and visibility of safety measures. For this analysis, we again ran multiple models and examined two types of self-reported feelings of safety: (1) respondents' ratings of how much each specific safety measure affects their feelings of safety, and (2) respondents' ratings of safety at the transit centers and on the buses. For the former, four different models were tested, with each using from Box C only the visibility of the specific safety measure being analyzed. For the models addressing safety at the transit centers and on the buses (including a separate model for riding after dark), however, all visibility measures were used simultaneously to allow for judging their independent effects on passenger safety. The results of these analyses are presented in Tables 6 and 7.

Table 6. Regression Models Predicting Passenger Response to Specific Safety Measures

	How the following affect feelings of safety at Transit Centers			
Independent Variables	Emergency Phones	More Police	Video Cameras	Increased Lighting
Days Rode	0.009	0.004	0.012	0.001
Lack Other Options	-0.011	-0.044	0.060	-0.003
Age	0.001	0.003	0.006*	0.002
Income	$-2.88\text{x}10^{-6}$	$-6.1\text{x}10^{-7}$	$-2.59\text{x}10^{-6}$	$-2.3\text{x}10^{-6}$
Sex	0.142*	0.030	0.040	0.186**
Notice Emergency Phones	0.300**	N/A	N/A	N/A
Notice More Police	N/A	0.175*	N/A	N/A
Notice Video Cameras	N/A	N/A	0.317**	N/A
Notice Increased Lighting	N/A	N/A	N/A	0.468**
Sample Size	589	644	641	615
R^2	0.04	0.02	0.04	0.084
Model Significance	0.000	0.100	0.000	0.000

*Significant at p<0.05.
**Significant at p<0.01.

Although the overall explanatory power of the models is relatively low—not a concern given that AATA riders almost unanimously agree that the service is quite safe (recall the high values on mean responses shown above), important predictive patterns due emerge. The clearest of these is that noticing the safety enhancements is far and away the most important explanatory factor for how passengers rate the safety value of specific enhancements. That is, riding patterns and rider characteristics have few effects independent of whether or not the passenger actually noticed the existence of the safety enhancement. In two cases, however, an independent effect of respondent sex was uncovered—emergency phones and, especially, increased lighting affect women's feelings of safety more than they affect men's. In both cases, the effect is in a positive direction—women report higher feelings of safety as a result of the enhancement. Additionally, age has a small, but significant, effect on the extent to which video cameras influence feelings of safety, leading older respondents to feel safer.

Table 7. Regression Models Predicting Passenger Ratings of Safety

	Passenger Ratings of Safety:			
Independent Variables	At BTC	At YTC	On Bus	On Bus after Dark
Days Rode	0.006	0.023	0.018	0.057**
Lack Other Options	-0.143	-0.260*	0.030	-0.179
Age	0.003	-0.002	0.001	-0.002
Income	$-7.7\text{x}10^{-7}$	$-5.2\text{x}10^{-6}$	$1.0\text{x}10^{-6}$	$-7.7\text{x}10^{-7}$
Sex	-0.250***	-0.419***	-0.07	-0.533***
Notice Emergency Phones	0.047	0.332**	0.045	0.051
Notice More Police	0.178**	0.274*	-0.042	0.270**
Notice Video Cameras (Centers)	0.004	-0.054	-0.046	-0.252*
Notice Increased Lighting	0.148*	0.324**	0.210***	0.169
Notice Video Cameras (Bus)	0.128	0.110	0.062	0.333**
Sample Size	571	368	645	505
R^2	0.054	0.108	0.029	0.103
Model Significance	0.000	0.000	0.046	0.000

*Significant at $p<0.10$. **Significant at $p<0.05$. ***Significant at $p<0.01$.

While passenger judgements of individual safety systems are interesting to transit operators, perhaps more important is how these systems affect passengers’ perceptions of safety in typical transit situations. The results in Table 7 indicate that safety enhancements and passenger characteristics (and to a lesser extent passenger riding patterns) have independent effects—that is, controlling for one another—on passengers’ ratings of safety. Most obviously, independent of noticing safety enhancement, women feel less safe than do men in three of the four situations tested. Noticing increased police presence and noticing lighting also both have several significant effects. On-board video cameras have a large effect on on-board feelings of safety, but only when riding after dark.

Because the data for this study derives from route-specific surveys, we were concerned with possible non-independence of observations within each route, i.e., heteroskedasticity. This situation could arise if, for example, a congenial driver made passengers on his or her route especially aware of the new safety improvements. To account for this possibility, we re-estimated the models using the Hubert/White/robust estimator of the variance-covariance matrix allowing for within-route correlated observations (but still assuming across-route observation independence). This estimator produces "correct" standard errors in the measurement sense, taking into account the sampling approach used (*12*).

The results of these robust models indicated that all significant coefficients estimated with the conventional method remained significant. Of the non-significant coefficients estimated the conventional way, only the coefficient of the Income variable in the Emergency Phones regression equation (see Table 6) became significant ($p<0.05$) with the robust estimator. Thus, we found little evidence of within route correlation of observations, and have increased confidence in the results reported above.

Discussion and Conclusions

Taken together, the results of this study reveal important patterns regarding passenger reactions to safety enhancements that should be of use to transit operators. At the broadest level, these results indicate that safety measures must be visible and noticed to influence perceptions of safety. Efforts to publicize safety improvements would seem well advised based on these results. Complementing this finding, the results also showed that the largest effects on the safety ratings were associated with those transit situations and places perceived as least safe by AATA passengers—in this case, waiting at the YTC and riding after dark. Indeed, the enhancement most noticed by respondents—on-board video cameras—proved effective in increasing feelings of safety only after dark.

Even when noticed, safety enhancements are limited (but by no means powerless) in their ability to affect transit passengers' feelings of safety, because a significant parts of those feelings are directly associated with characteristics of the passengers and not the service. Most clearly, women simply feel less safe than men. On the other hand, women also proved more observant of safety enhancements, which means that as a group they gain the most peace of mind from safety enhancements.

Finally, future work in this area should serve to link perceptual work with more objective measures of transit safety. We suspect that safety incidents can be expected to influence both the visibility of measures taken to improve safety and passengers' perceived safety. While methodological issues promise to complicate linking the more objective and more subjective worlds (e.g., even a crime-ridden bus route may not influence passengers who use that route but are fortunate enough to avoid runs that are crime involved), the effort promises to be worthwhile. Data regarding transit crime and other incidents, both on-board transit vehicles and at stops and stations, should provide added explanatory power for gauging passengers' feelings on transit safety and allow researchers and transit operators to differentiate between safety measures that affect perceptions only and those that truly reduce the number of incidents. If we are fortunate, these will be the same measures, but they need not be.

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