Accident Analysis and Prevention 82 (2015) 90–100

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Metro passenger behaviors and their relations to metro incident involvement

Xin Wan[a,*], Qiming Li[a], Jingfeng Yuan[a], Paul M. Schonfeld[b]

[a] Department of Construction and Real Estate, School of Civil Engineering, Southeast University, Nanjing, Jiangsu 210096, PR China
[b] Department of Civil and Environmental Engineering, University of Maryland, College Park, MD 20742, USA

ARTICLE INFO

Article history:
Received 9 March 2015
Received in revised form 21 May 2015
Accepted 25 May 2015
Available online 6 June 2015

Keywords:
Rail transit safety
Passenger behaviors
Incidents
Violations
Errors

ABSTRACT

The frequent incidents caused by metro passengers in China suggest that it is necessary to explore the classification and effects of passenger behaviors and their relations to incident involvement. A metro passenger behavior questionnaire (MPBQ) and a metro station staff questionnaire (MSSQ), both comprising 32 behavior items, were developed and surveyed on a sample of metro passengers ($N = 579$) and metro staff ($N = 99$). Using the MPBQ, the self-reported frequency of each aberrant behavior was measured and subjected to explanatory factor analysis, which revealed a three-factor solution on the 28 retained behavior items: transgressions, self-willed inattentions and abrupt violations. ANOVA was used to examine the effects of demographic and riding profile variables on different types of behaviors. The MSSQ was used to collect metro staff opinions on behavior frequency, severity and entities that might be affected, given that a specific behavior occurred. An importance hierarchy was established over the 32 identified behaviors to determine the most important riding behaviors. Finally, logistic regression showed that riding time, number of stops experienced by a passenger and, more importantly, transgressions and abrupt violations, were significant predictors of incident involvement. The possible explanations and implications of the findings might help in understanding passenger behaviors and targeting metro safety interventions in ways that promote safer operations.

1. Introduction

1.1. Metro passenger behaviors and metro safety

Rapid urbanization progress in China has greatly boosted the initiation of urban metro[1] projects. As a result, by 2012, 28 cities had 63 metro lines under construction and 64 metro lines in 17 cities were in service. However, along with starting service on numerous metro lines come not only the benefits of road traffic relief and environmental pollution reduction but also new challenges and demands for reliable and safe metro operation.

Many of the metros in large cities of China experienced high intensity of transit (Zhang et al., 2008; Shen et al., 2015). This crowding can be revealed by the annual ridership per unit of metro length. In 2013, for example, the ridership (in millions) per mile of New York metro was 7.4 (MTA, 2013), while reaching 14.4 and 10.1 for the Guangzhou metro and Beijing metro, respectively (Shen et al., 2015). Chinese motorists generally receive less traffic safety training than Western motorists and receive it later in their lives. Although the situation is improving in the younger Chinese generation, as argued by Shi et al. (2010) in their study on Beijing driver behaviors, this would potentially reduce the global risk awareness of the general public. Moreover, metro riding rules are not as strict and explicit as traffic regulations, and sometimes can be violated without a similarly stringent punishment (Wan et al., 2014). All these conditions in China (crowded riding environment, low risk awareness and less strict rules) may contribute to aberrant riding behaviors in metro systems and increase the risk of passenger-involved metro accidents or incidents.

Since no official accident data can support case statistics, a total of 135 metro operation cases within the time span from 2002 to 2012 were collected nationwide via Internet and interviews with metro employees. Among these, 88 cases (65% of the total) are due to metro passenger behaviors (MPBs) (Wan et al., 2014), resulting in 19 min average operation delay and a total of 17 deaths and 40 injuries. Besides, no declining trend of MPB rates is observed in recent years despite the rapid increase in total metro length, for the number of incidents per 100 miles in 2010, 2011 and 2012 were 1.3, 1.7 and 1.7, respectively. These figures may not fully reflect the

* Corresponding author. Tel.: +86 25 83793697; fax: +86 25 83793251.
E-mail address: wanxin_34@163.com (X. Wan).

[1] "Metro" in this study referred to underground or largely underground rail transit systems in urban areas, also known as "Heavy Rail Transit".

http://dx.doi.org/10.1016/j.aap.2015.05.015
0001-4575/

status quo of MPB risks because only major cases (e.g., those causing severe damage or social response) that received media coverage were collected, while many minor cases which were potentially dangerous (e.g., causing congestion, quarrels, or small interruptions) were omitted due to lack of detailed data. Consequently, the current state of MPB effects can be expected to be worse. Since aberrant riding behavior is becoming a noticeable cause of metro incidents and shows no signs of improvement, understanding the nature of passenger behaviors and identifying their relations to incident involvement should provide worthwhile safety improvements.

In reality metro passengers are often observed to cause incidents[2] that to some degree merely affect system operation. Beijing metro, for example, suffered local degraded operation for 70 min on November 3 and 4, 2011 due to two incidents of forcing train doors to stay open. Such incidents that lead to many negative effects (e.g., congestion and delay) even without casualties should be taken into account when metro safety issue is discussed. Therefore, safety concerns of metro operation are extended in this context to cover both the safety of passengers who may potentially be involved and the normality of system operation that may potentially be interrupted in an incident. This is somewhat different from road safety concerns, where the casualties in an accident are the most common focus of attention. The necessity of this extension lies in defining the basic scope of behavior identification and measurement in this study.

To date, MPB incidents are still frequently noted in the news. An occurrence during APEC 2014 caused a sensation and is just one example among many MPB incidents. A woman was sandwiched between the safety door and the train door when boarding at a crowded station of Beijing metro and was killed by the departing train. The incident also resulted in 20 min delay of metro line 5. Based on this case, in considering influencing factors for passenger-involved incidents, it is essential to examine three factors: (a) machines and (sub-) systems (e.g., safety doors, train systems); (b) environments (e.g., facilities, other passengers, metro staff); and (c) human factors (e.g., passengers). A number of studies regarding metro safety emphasized the exploration of critical elements in the first two factors (e.g., Burnett and Pang, 2004; Li et al., 2011, 2012; Wang and Fang, 2014). Few researchers sought to reduce metro risks by interpreting human behaviors, although the relation between users' behaviors and traffic safety has been extensively explored in other domains, such as road safety (e.g., Reason et al., 1990; Aberg and Rimmo, 1998; Elliott and Baughan, 2004).

1.2. Research related to metro passenger behaviors

To our knowledge, no systematic research has explored the MPBs' structure and influence elements. Suicide behavior is the first and only specific aberrant behavior that has been given much attention by some researchers. Since O'Donnell and Farmer's (1992) study, characteristics and patterns of suicide behaviors were examined in New York (Gershon et al., 2008), Germany (Ladwig and Baumert, 2004; Erazo et al., 2005; Dinkel et al., 2011) and Vienna (Niederkrotenthaler et al., 2012), mostly in view of epidemiology. Factors such as age, gender, location, time and season variation were found to have connections with the incidence of metro suicide. Besides, several studies have investigated the non-risky aspects of the MPBs, such as the tactile behavior in the New York metro (Maines, 1977) and incentive policies to change commuters' behavior in the Beijing metro (Zhang et al., 2014).

Ethological observation including field observation and experimental observation is deemed an effective tool for social behavioral research, especially for examining the environmental effects on traffic behaviors in a given scenario (Leandro, 2012; Zeedyk and Kelly, 2003; Sisiopiku and Akin, 2003). However, observation method may be inapplicable when tackling aberrant behaviors that may be difficult to observe and occur in different contexts. Another method consists of conducting a self-report questionnaire survey which, though fraught with possible biases, provides a useful framework within which several important issues can be discussed, such as which type of behavior predict metro incidents, which group of passengers is prone to aberration and what psychological mechanism underpins different types of aberrant behaviors.

The driver behavior questionnaire (DBQ) initially developed by the Manchester Driving Behavior Research Group (Reason et al., 1990) provides a good example of a method for exploring the structure of MPBs. Using the DBQ, aberrant driving behaviors were empirically classified as a system of violations, errors and lapses. Later, Parker et al. (1995) confirmed the three-factor structure of the DBQ and concluded that this instrument is reliable over time by examining the consistency between the original test and the retest after seven months.

The benefit for the violation-error classification is that the difference of the psychological mechanism underpinning the two types of behavior leads to different remedial actions (Reason et al., 1990). In general, violations related to a motivation factor may be reduced by metro safety education aiming at changing the actor's attitude and beliefs to specific type of behaviors; errors resulting from the failure of cognitive skills are remediable by training campaigns regarding skill improvement. Another benefit is that the respective contributions of different types of behaviors to metro incidents can be measured. It is violations that were frequently found to be the predictor of driver crash involvement (Parker et al., 1995; Gras et al., 2006; Sullman et al., 2002). Error factors for two-wheeled riders (e.g., motorcyclists) were also predictive of crash involvement (Elliott et al., 2007).

Next, distinctions should be made between violations and errors based on previous studies (Reason et al., 1990). Violations are generated in a social context in which behaviors are governed by practices, rules and norms, whether formally or informally; errors are unintentional failures in individual cognitive process. Considering where the deficiency occurs, errors can be further divided into mistakes and slips or lapses. The former concerns failures in intentions that are inappropriate to the situation. The latter refers to unintentional departures from a desirable action. Violations generated in metro systems are mainly departures from riding rules or norms with some degree of intentionality but their aims are not to cause damage or injury. If the departure between the action and socially established practices is involuntary, it is an error.

The distinctions between violations, errors and lapses were given more weight by the differences among relative variables. It was found that male drivers, young drivers and drivers with more mileage committed more violations and errors (Parker et al., 1995; Aberg and Rimmo, 1998), while women (Reason et al., 1990; Parker et al., 1995; Parker and Xie, 2002) and older drivers (Aberg and Rimmo, 1998; Kontogiannis et al., 2002) had more lapses.

The validity of the DBQ instrument has been broadly confirmed across the UK (Parker et al., 1995; Blockey and Hartley, 1995), Australia (Lawton et al., 1997; Aberg and Rimmo, 1998) China (Parker and Xie, 2002; Shi et al., 2010), Greece (Kontogiannis et al., 2002), New Zealand (Sullman et al., 2002), Finland (Mesken et al., 2002), Spain (Gras et al., 2006; Sullman et al., 2011) and

[2] A more extensive term "incident" instead of "accident" was used in this study to encompass any potentially hazardous aberrant events, either with or without substantive damage consequences (e.g., congestion, costs, delays and loss of lives).