QUALITY OF RAIL PASSENGER EXPERIENCE: THE DIRECT AND SPILLOVER EFFECTS OF CROWDING ON INDIVIDUAL WELL-BEING AND ORGANISATIONAL BEHAVIOUR

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ABSTRACT

The challenge of rail passenger crowding has not been fully addressed in the scientific literature. This thesis describes a research work aimed at (1) investigating the relationships among the different psychological components of crowding and their effects on commuters' experience of stress and feelings of exhaustion, and (2) exploring how the effects of rail passenger crowding can spill over to the individual's broader work and life. To achieve these aims, an operational model is built that is consistent with the framework of Cox et al.'s (2006) model of crowding, stress, health, and safety, and is tested in a two-phase study. While Phase One of the research qualitatively explored the perceptions of rail passenger crowding and other associated issues among key stakeholder institutions (N = 5), Phase Two quantitatively examined the effects of rail passenger crowding on commuters' individual well-being and their organisational behaviours (N = 525). The results of Phase One demonstrate that passenger crowding is perceived only as a minor problem compared to capacity, infrastructure, and service quality issues among the key stakeholders. On the other hand, the results of Phase Two reveal that crowding is indeed stressful for the commuters and has the potential to spill over to other aspects of their life and work. Using structural equation modelling techniques, the results show first the relationships among passengers' evaluation of the psychosocial aspects of the crowded situation and of its ambient environment as well as their affective reactions to it, and the relationships among these psychological components of crowding and passenger density. Second, they demonstrate that the different psychological components of crowding together with rated passenger density are combinatorially predictive of commuters' stress and feelings of exhaustion. Third, while the effects of crowding on feelings of exhaustion disappeared after controlling for demographic factors and individual differences in commuting experience, its effects on the experience of stress remained significant, further highlighting the negative consequences of rail passenger crowding. Fourth, the results reveal different patterns of spillover effects for passenger stress, particularly on commuters' reports of somatic symptoms of ill health, their propensity for lateness and absenteeism at work, and intention to quit, but not in terms of their job or life satisfaction. The implications of these findings are discussed in terms of the existing literature and the operational framework set out at the beginning of the research work, which could lend support for future crowding research and management.

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This thesis would never have taken shape without the unfailing encouragement, insight, and advice of my supervisors - Professor Tom Cox CBE and Professor Amanda Griffiths. Considerably understanding and unwaveringly positive, Tom provided me with the confidence to persevere this lonely and rugged journey even when a catalogue of unforeseen circumstances presented challenges along the way. I learned most from his optimistic nature and have drawn the determination to complete this journey from his strength and willpower. My appreciation also goes to Amanda, who, despite all her other responsibilities, was able to offer helpful suggestions throughout this endeavour.

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This thesis represents a culmination of work, passion, and commitment to address issues and concerns regarding public transport conditions in Malaysia. It is dedicated to those individuals striving to make a difference and raise awareness in their own way, and especially to those who have faced all odds strongly and have survived every hardship with patience, frankness, wisdom, and above all, humility.

In the end, all things and all knowledge belongs to Him,
the Most Learned, the Most Aware.

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CHAPTER 7 - PASSENGER SURVEY

PREFACE

Previous studies have shown the association between crowding and negative outcomes as evidenced in various theories pertaining to human crowding (Bell, Green, Fisher, & Baum, 2001; Baum & Paulus, 1987; Edney, 1977). Unfortunately, the challenge of rail passenger crowding has not been fully addressed in the scientific literature. Passenger crowding is a major concern not only for those using rail transport but also for those who manage rail systems worldwide (Cox, Houdmont, & Griffiths, 2006). Many train companies operate with limited systems capacity and with a steadily increasing passenger constituency, especially in urban commuting areas.

Commuting on a crowded train can be both a time-consuming and a draining experience for passengers, sometimes characterised by stress and frustration (Cox et al., 2006; London Assembly Transport Committee, 2009a). Operating overcrowded trains is a problem for train companies, as it may be associated with delays in services (Lam, Cheung, & Lam, 1999; Lam, Cheung, & Poon, 1999), injuries to staff and passengers, wider health and safety issues (Turner, Corbett, O'Hara, & White, 2004; Cox et al., 2006) as well as being a vehicle for the spread of illness and disease (Gershon, Qureshi, Barrera, Erwin, & Goldsmith, 2005). Despite this, there is insufficient research into the nature and effects of crowding on rail passengers, including commuters. This is particularly true in the Malaysian context, where there is a paucity of research focusing exclusively on the perception of and reaction to crowding in public transport.

In an attempt to address this issue, this thesis sought to explore the relationships among the different psychological components of crowding and their effects on commuters' experience of stress and feelings of exhaustion. It also considers possible spillover effects in terms of individual and work outcomes. This research programme draws on two key areas of the crowding literature - the nature and conceptualisation of crowding and the effects of crowding. By doing so, the present work serves the threefold purpose of bridging theory, research, and practice. First, past research is inconclusive, as there is a distinct lack of sound, empirical support for the effects of rail passenger crowding on stress and other associated outcomes. The findings of the present work clarify and make more concrete the evidence of these effects. Second, this research sheds light on the underlying mechanisms and psychological processes involved in the experience of crowding and its associated consequences. Finally, the findings offer useful information for governmental and non-governmental agencies in developing management strategies and implementing proactive interventions than can reduce the effects of crowding in the rail passenger context, and possibly, in other transportation settings as well.

This thesis is organised into eight chapters. Chapter 1 [*Introduction*] gives a broad overview of the research work presented in this thesis. It describes the background of the research and outlines the focus and scope of the study, and explains the motivation for pursuing this line of research.

Chapter 2 [*The Nature and Effects of Rail Passenger Crowding: A Systematic Review of the Literature]* focuses on reviewing previous research in this area, taking the study of crowding and density on rail transportation as a starting point, and drawing out the evidence that illuminates the definitions, measurements, and consequences of crowding within this context. First, the conceptual distinctions between crowding and density and the contextual aspects of crowding in relation to the transportation studies are discussed. Next, the systematic review process undertaken to investigate the evidence that has been gathered on the consequences of rail passenger crowding is described in detail. The chapter not only reveals that there are potential risks and effects of crowding on passengers but also highlights the need for a valid and reliable measure of crowding on rail transportation and the relative inadequacy of the existing theoretical frameworks in addressing this issue. Findings from this systematic review are used to identify areas for further research, which form the basis for the specific research questions of the thesis.

Chapter 3 [*Conceptual Development*] first evaluates the different conceptual-theoretical perspectives of the human response to crowding and then justifies the theoretical approach underlying this thesis. It is argued that the integrative nature of the Cox et al. model (2006) offers a coherent analytical framework to address critical issues concerning passenger crowding and its associated outcomes. From this model, a new operational model is proposed and discussed. The chapter concludes by presenting the research questions and hypotheses that this thesis investigates and providing an explanation of the current model components.

Chapter 4 [*Research Strategy and Methodology*] highlights the specific research questions and hypotheses and discusses the appropriate methodologies for approaching the topic. On the basis of evidence from the systematic review and exploration of the differences between possible theoretical frameworks and research designs, the chapter argues that the best way to investigate the relationships among the different psychological components of crowding and their effects on commuters' experience of stress and feelings of exhaustion and its possible spillover effects is to use a combination of a descriptive and an exploratory approach that involves the collection of qualitative and quantitative data from a wide range of stakeholders. Additionally, the chapter has justified the decision to use structural equation modelling (SEM) as an analytical approach that is fit for purpose given the problem under study. The chapter then concludes by discussing the research design that was adopted for data collection and addressing the practical issues of sampling, measurement, and research ethics.

As the starting point, the first phase of the study collates the essential background information and sets the context for this thesis. Chapter 5 [*Key Stakeholder Scoping Survey*] reports the findings of a scoping survey involving key players in the Malaysian rail industry. This study specifically examined the issues and concerns that the government, train operating companies, and non-governmental transportation groups have regarding rail passenger services, particularly those that are more crowding-related. The study highlights, among other things, the relative lack of recognition of passenger crowding as a significant problem in the rail industry despite the high ridership growth and the emphasis on governance, policy, engineering, and economic-based interventions for rail transport development. The chapter concludes by re-emphasising the need for an empirical study that explores the more psychological components of crowding among the most important stakeholder group - the commuters or passengers - in order to further investigate the effects of rail passenger crowding.

Chapter 6 [*Measuring Rail Passenger Crowding: Scale Development and Psychometric Properties*] first sets the theoretical basis for the development of a scale to measure the different psychological components of crowding. Addressing research question one, this chapter describes the development of an instrument that gauges the experience of crowding among rail commuters. Exploratory and confirmatory factor analyses showed strong evidence that the instrument developed in this study is an internally consistent, three-factor structure with a good model fit and has sufficiently good construct, convergent, and discriminant validity values to support its use as a measure of crowding experience. The chapter concludes by discussing the potential utility of the instrument.

Chapter 7 [*Passenger Survey*] presents a cross-sectional survey examining the impact of rail passenger crowding on the passengers in a sample of 525 respondents who commute to work by train frequently across Kuala Lumpur and its suburbs. This chapter frames the argument of the thesis on the examination of how the variables under interest influence the outcomes in one model. In particular, the contribution of the new measurement instrument of crowding experience (Chapter 6) in explaining the effects of rail passenger crowding on commuters is shown in this chapter. By performing a series of multivariate analyses such as hierarchical multiple regressions and path analyses, the negative effects of the psychological components of the experience of crowding on passenger stress and the associated spillover effects are revealed. The chapter proceeds by interpreting the findings and presenting answers to all research questions and hypotheses posed in Chapter 3. The chapter concludes by discussing how the research aims were achieved in that a final model depicting the relationships among the psychological components of crowding and their direct and spillover effects on both individual and work outcomes has been developed and empirically validated.

Chapter 8 [*General Discussion, Implications, and Future Research*] summarises the evidence obtained from both key stakeholder and passenger surveys. Next, the implications of the research's results for theory, measurement, practice, and policy are discussed. Some theoretical and methodological issues arising from this research are also acknowledged and elaborated. The chapter concludes by highlighting the contributions that the thesis has made to understanding rail passenger crowding and presenting suggestions for further research which may be undertaken in continuation of this work.

PUBLISHED WORKS

The thesis contributions have essentially extended the body of scientific research into crowding, particularly in the psychological and transportation research areas. In an ongoing process, the work has been disseminated to both academia through conference inputs, book chapters, and journal articles, and the industry via meetings and direct contact.

Parts of this thesis have been published in the following refereed publications:

1. Mohd Mahudin, N. D., Cox, T., & Griffiths, A. (2012). The measurement of rail passenger crowding: Scale development and psychometric properties. *Transportation Research Part F: Traffic Psychology and Behaviour, 15* (1): 38-51.

2. Mohd Mahudin, N. D., Cox, T., & Griffiths, A. (2011). Modelling the spillover effects of rail passenger crowding on individual well-being and organisational behaviour. In A. PRATELLI & C. A. BREBBIA (Eds.), *Urban Transport XVII, Urban Transport and the Environment in the 21st Century*. WIT Transactions on the Built Environment. WIT Press, UK, pp. 227–238.

The works described in Chapters 2, 6, and 7 have also been presented for discussion at the following conferences and seminar:

1. Mohd Mahudin, N. D., Cox, T., & Griffiths, A. (2011). *Modelling the spillover effects of rail passenger crowding on individual well-being and organisational behaviour.* Paper presented at the 17th International Conference on Urban Transport and the Environment, June 6-8, 2011 at the University of Pisa, Italy. [Paper published in refereed conference proceedings].

2. Mohd Mahudin, N. D., Cox, T., & Griffiths, A. (2010). *Commuting stress: Consequences and implications for employee well-being*. Paper presented at the 25th PsyPAG Conference 2010, July 21-23, 2010 at Sheffield University, United Kingdom.

3. Mohd Mahudin, N. D., Cox, T., & Griffiths, A. (2009). *Conducting systematic reviews in psychology: Issues, challenges, and opportunities*. Paper presented at the Southeast Asia Psychology Conference (SEAP) 2009, July 9-11, 2009 at University Malaysia Sabah, Malaysia. [Paper published in refereed conference proceedings].

4. Mohd Mahudin, N. D. (2009). *Quality of rail passenger experience: The effects of crowding on health, comfort, and stress: A systematic review.* Invited talk at Seminar on Issues in Psychology, May 18, 2009, organised by the Department of Psychology, International Islamic University Malaysia.

A further four publications are currently in press, under revision, or under review. These publications are based on the studies described in Chapters 2, 6, and 7.

1. Mohd Mahudin, N. D., Cox, T., & Griffiths, A. (In press). Conducting systematic reviews in psychology: Issues, challenges, and opportunities. Paper originally presented at the Southeast Asia Psychology Conference (SEAP) 2009 and selected as a book chapter in the *Industry and Organizational Psychology Issues in Southeast Asia* by Publication Unit, Universiti Malaysia Sabah.

2. Mohd Mahudin, N. D., Cox, T., & Griffiths, A. The effects of rail passenger crowding on health and stress: A systematic review. Manuscript submitted to *Transportation*, Springer [Currently under revision].

3. Mohd Mahudin, N. D. Multiple effects of rail passenger crowding: Evidence from Malaysia. Manuscript submitted as a book chapter in the *Contemporary Issues in Malaysian Psychology*, 2nd Edition, by Thomson Publishing [Currently under revision].

4. Mohd Mahudin, N. D., Cox, T., & Griffiths. A. Transfer effects and permeable boundaries: An empirical study of the effects of commuting stress on employees' work and life. Manuscript submitted to *Southeast Asia Psychology (SEAP) Journal*, University Malaysia Sabah [Currently under review].

Outside the thesis work, and in addition to the publications listed above, the author has authored and co-authored the following publications throughout her Ph.D candidature.

1. Griffiths, A., Knight, A., & Mohd Mahudin, N. D. (2009). *Ageing, work-related stress and health: Reviewing the evidence*. London, UK: Help The Aged. [Report from commissioned research].

2. Mohd Mahudin, N. D. (2009). Social psychology. In Noor, N.M. (Ed.), *Psychology from an Islamic perspective: A guide to teaching and learning*. Kuala Lumpur: IIUM Press. [Book chapter].

3. Noor, N. M., Alias, A., Abdullah, F., Abdul Majid, H. S., Abdul Hamid, H. S., Fauzaman, J., Dzulkifli, M. A., Mohamed Iqbal, M. I., Samsudin, M. Z., Mohd Mahudin, N. D., & Abd Rahman, S. (2009). *The IIUM Religiosity Scale (IIUMRelS)*. Department of Psychology, International Islamic University Malaysia. [Research report].

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LIST OF ABBREVIATIONS AND ACRONYMS

AIC	Akaike's Information Criterion
AMOS	Analysis of Moment Structures
ART	Advanced Rapid Transit
CFI	Comparative Fit Index
CoMET	Community of Metros
CVR	Content Validity Ratio
DOC	Degree of Crowding
DOR	Department of Railways
EMU	Electric Multiple Unit
ETS	Electric Train Set
GMPTE	Greater Manchester Passenger Transport Executive
GTP	Government Transformation Programme
GWBQ	General Well-Being Questionnaire
KTMB	Keretapi Tanah Melayu Berhad (Malaysian Railway)
ITIS	Integrated Transport Information System
LOS	Levels of Service
LPTAs	Local Public Transport Authorities
LPTC	Land Public Transport Commission
LRT	Light Rail Transit
MANOVA	Multivariate Analysis Of Variance
ML	Maximum Likelihood
MOT	Ministry of Transport
MSQ	Minnesota Satisfaction Questionnaire
NGO	Non-Governmental Organisation
NKRA	National Key Result Areas
NPTA	National Public Transportation Authority

PAF	Principal Axis Factoring
PEMANDU	Performance Management and Delivery Unit
PIXC	Passengers in Excess of Capacity
PNFI	Parsimonious Normed Fit Index
pphpd	passengers per hour per direction
PUTRA LRT	Projek Usahasama Transit Ringan Automatik Sdn Bhd
RapidKL	Rangkaian Pengangkutan Integrasi Deras Sdn Bhd
RAC	Railway Assets Corporation
RMSEA	Root Mean Square Error of Approximation
RSSB	Rail Safety and Standards Board
SACL	Stress and Arousal Checklist
SEM	Structural Equation Modelling
SMART	Stormwater Management and Road Tunnel
SPAD	Suruhanjaya Pengangkutan Awam Darat
SPNB	Syarikat Prasarana Negara Bhd
SPSS	Statistical Package for the Social Sciences
SRMR	Standardised Root Mean Square Residual
STAR LRT	Sistem Transit Aliran Ringan Sdn Bhd
SWLS	Satisfaction with Life Scale
TRANSIT	The Association for the Improvement of Mass Transit
UPT	Urban Public Transport
VIF	Variance Inflation Factor

CHAPTER 1 - INTRODUCTION

1.1 Chapter overview

This chapter presents a broad overview of the research work reported in this thesis. It describes the background to the problem and context for the thesis, outlines the focus and scope of the research, and explains the motivation for pursuing this line of work. The issues raised by previous research concerning perceived crowdedness or crowding, particularly its relationship to the experience of stress and potential spillover effects, are addressed. The chapter then concludes by summarising the contributions of the thesis and discussing the importance of the present work.

1.2 General statement of the problem area

As the demand for rail travel continues to grow amongst the travelling public, along with fuel price increases, traffic congestion, and employment and population growth, overcrowding of rail services is fast becoming a pressing concern worldwide, including in Malaysia. Current estimates show that the main rail lines in Malaysia are functioning at over 140 and 180% of design capacity (Performance Management and Delivery Unit (PEMANDU), 2010). The notion that passengers are being crammed into trains like cattle or cramped like sardines in a small tin on the trains is also not uncommon elsewhere (London Assembly Transport Committee, 2009b; Cox et al., 2006). For this reason, train overcrowding is being recognised increasingly as a potential threat to physical health, personal safety, psychological well-being, and even the quality of life (London Assembly Transport

Committee, 2009a; Cox et al., 2006; Turner et al., 2004; House of Commons Transport Committee, 2003).

Research into the nature and effects of rail passenger crowding on commuters is relatively limited (Cox et al., 2006). At present, our knowledge is constructed not only from studies of rail travel but also from those involving other forms of transport. Most rail-related crowding research, however, focuses on the direct effects of crowding, such as psychological and physiological stress as well as commuting satisfaction (for example, Cantwell, Caulfield, & O'Mahony, 2009; Evans & Wener, 2007; Buckley & O'Regan, 2004), but with an emphasis on physical environmental variables, such as passenger density or train capacity, as the determinants of these outcomes. The extant rail literature, for the most part, overlooks the roles that the different psychological components of crowding play in determining both its direct and spillover effects.

One emerging variable of interest that has not been well investigated in commuting and rail literature is perceived crowdedness or crowding (Cox et al., 2006; Turner et al., 2004) - a negative, subjective state of psychological stress that arises from a situation of scarce space (Stokols, 1972a; 1972b). Given the extensive physical crowding that most rail services are already experiencing as well as the increasing safety concerns among passengers reported in the media, crowding is an issue gaining the attention of policymakers and the general public. The situation is further exacerbated by the issue of the high costs of increasing train capacity and developing rail infrastructure among the rail operators (Henn, Karpouzis, & Sloan, 2010; House of Commons Committee of Public Accounts, 2010). As a result of this issue, insufficient efforts have been made to develop strategies for managing train overcrowding. Among the various implications these developments have that are relevant to the current research are that:

(1) the increasing demand on existing rail services continues to put a strain on the system's capacity and adversely affects service levels and commuters' satisfaction, and (2) rail passengers have to routinely endure even worse levels of overcrowding (House of Commons Committee of Public Accounts, 2010). Hence, addressing the possible underlying psychological processes of how crowding affects rail commuters has become a critical issue.

The negative effects of crowding on commuters have potential implications for health and safety issues, deterioration in service quality, and, ultimately, commuters' individual well-being and organisational behaviour. Both the environmental psychology and transport literature consistently demonstrate the adverse effects of crowding on psychological and physiological stress (Bell et al., 2001; Baum & Paulus, 1987). For instance, crowding has been found to be associated with higher rates of illness and multiple infections (Clauson-Kaas et al., 1997; Fleming, Baum, & Weiss, 1987), increases in negative reactions, social withdrawals, and aggressive behaviours (Haney, 2005; Baum & Davis, 1980) as well as impairments in learning and task performance (Knowles, 1983; Evans, 1979). In the rail-related literature, crowding on trains or at station platforms has been found to affect passenger stress and frustration (Evans & Wener, 2007; Cox et al., 2006) and to influence individuals' susceptibility to illness and disease (Gershon et al., 2005; Taylor & Pocock, 1972).

From a relatively small number of empirical studies, the spillover effects of crowded commuting have been found to be associated with a variety of individual work and organisational outcomes, including work-related stress, decreased productivity, reduced job satisfaction, late arrival at work, and sickness absence (Cox et al., 2006; Passenger Focus, 2006; House of Commons Transport Committee, 2003). The use of the spillover concept is clear in the research of Cox et al. (2006;

2003) in which a working model of passenger crowding, stress, and health and safety is proposed. According to their model, passenger density may lead to perceived crowding, although the relationship is imperfect. Perceived crowding may then drive the experience of stress, which, in turn, may result in a multiplicity of outcomes in both individual and work domains. This model assumes that the impact of high passenger density and the perception of crowding on health and safety-related outcomes is mediated by the experience of stress, and that this overall process is moderated by factors such as perceived control, commute predictability, level of behavioural constraint, level of arousal or activation, and perception of risks. Nonetheless, the development of Cox et al.'s model is constrained by a lack of empirical data to validate its use as a tool for both understanding passenger crowding and investigating its possible spillover effects. Thus, the present research attempts to provide the necessary empirical data to test and develop the model.

In essence, the underlying premise of this research is that achieving an understanding of the relationship between passengers' experience of crowding and its associated outcomes is important, but the area has been little researched. Given its likely impact on physical health, psychological well-being, and organisational behaviour, it appears that the different psychological components of crowding may play a pivotal role in influencing passengers' commuting experience. To date, the limited existing rail literature focuses mainly on the direct effects of crowding on commuters. The present research extends the literature by addressing this gap and responding to Cox et al.'s (2006) call for coordinated approaches to examining the potential spillover effects of crowding to other aspects of passengers' life and work.

1.3 Importance of and motivations for the research

This research has been motivated by four main factors. First, the significant change in urban transport has greatly modified individuals' commuting pattern and influenced their travel well-being. Commuting has become an integral part of working life for most workers, including those in Malaysia. Together with rising incomes, growth of the suburbs and access to modern modes of travel have all enabled people to live further away from their workplace (Ensor, 2004). As a result, commuting to work either by private or public transport has become considerably more demanding than it was before. However, unlike research into environmental variables, interpersonal relationships, personal characteristics, and organisational factors, all of which are empirically supported as being major sources of stress, evidence of the effects of commuting on employees' well-being in Malaysia from a psychological perspective is relatively scarce.

Second, while the spillover effects of tangible commuting factors, such as the distance and duration of the journey, have been studied (Wener, Evans, & Boately, 2005; Wener & Evans, 2004; Novaco, Stokols, & Milanesi, 1990), the more psychological processes remain relatively unexplored. It is a logical supposition that the experience of stress related to passenger crowding mediates or moderates many of its effects, directly or indirectly. However, the role of the experience of stress has not been extensively studied in this context. Studies elsewhere consistently demonstrate the adverse effects of crowding on psychological and physiological stress (Bell et al., 2001; Baum & Paulus, 1987). The pathways that may link the different components of the passenger crowding process have not been adequately explored. In particular, with some exceptions, crowding has been largely ignored as a potential source of commuter stress.

The third motivation for the research is to address the lack of a comprehensive definition and conceptualisation of crowding experience in the rail literature. The differing views on the definition and construct of crowding as well as on its measurement attributes are discussed in Chapters 2, 4, and 6. The interest of the current work is thus primarily driven by a research motivation to identify and quantify the different components of the experience of crowding which can be shown to affect negative outcomes.

Finally, knowing the consequences of passenger crowding and crowded commuting (for example, stress, feelings of exhaustion, and spillover effects) can generate new possibilities for the development of a variety of interventions that may attenuate both the direct effects of passenger crowding and any spillover effects. For example, rail operators and relevant authorities can use such interventions to facilitate improvements in service quality and enhance crowd management policies and initiatives.

1.4 Purpose of the research

Given the above issues and influences, this thesis aims to investigate the relationships among the different psychological components of crowding and their direct effects on commuters' experience of stress and feelings of exhaustion. It also considers possible spillover effects in terms of both individual and work outcomes. Specifically, the research aims can be broken down into several sub-issues, which the thesis seeks to address. Firstly, it seeks to investigate how the experience of crowding can affect passengers' commuting experience and their overall well-being. The thesis also seeks to understand the construct of crowding experience by exploring the distinctions between the crowding experience, the essentially psychosocial characteristics of the crowded situation, and those of its ambient environment. The thesis also strives to investigate potential interventions that can be made to mitigate the consequences of crowded commuting. In addressing these issues, five research questions and eleven hypotheses were proposed and discussed in detail in Chapter 3. Answers to these questions and hypotheses were then sought through a scoping survey with key stakeholders (Chapter 5), the development of an instrument for measuring the experience of crowding (Chapter 6), and a questionnaire survey with commuters (Chapter 7).

1.5 Scope and delimitations of the research

In order to achieve clarity and focus, several issues have to be excluded from the scope of the thesis. First, this thesis does not attempt to statistically analyse the causal impact of crowding on its associated outcomes. Instead, the focus is on the use of regression and path analysis models that quantitatively represent the relationships among these variables. In doing so, the thesis develops a fuller understanding of the pathways that may link the different components of passengers' crowding experience with its direct and spillover effects at both individual and organisational levels.

From the outset, it is important to note the distinction that the thesis adopts in differentiating the objective and subjective dimensions of crowding. The two dimensions are related, as high-density situations (the objective dimension) have been found to affect both perceived crowding and induce affective feelings of crowdedness (Cox et al., 2006; 2003). However, research has also shown that density may not always be associated with negative evaluations or effects (Stokols, 1972a; 1972b). This thesis deals with the different psychological components of crowding experience and examines how these components interact with passenger density. The main focus is therefore the subjective components of crowding and not the objective, physical aspect of passenger density.

This research was also delimited to examining the effects of crowding on passengers' stress, feelings of exhaustion, and life and work outcomes in rail transportation settings. Therefore, this thesis could not accommodate a more extensive discussion of the effects of crowding across varying research contexts or settings. Additionally, the present work was conducted using Malaysian samples and the scope of the research was limited to four types of rail lines, although relevant information from other railways and non-railway situations were also considered. Thus, the results of this research should be interpreted within the boundaries of the stated contexts.

1.6 Thesis importance and contributions

Having discussed the motivation, scope, and purpose of conducting this research programme, it is fitting to conclude this chapter by detailing the overall contributions of the thesis. Continuing previous work done in this field, the main contributions of this thesis are:

1. an updated and extensive empirical assessment of the definitions, measurements, and effects of crowding in relation to transportation studies, focusing on the identification of key variables associated with the different psychological components of crowding, passenger density, experience of stress, feelings of exhaustion, and spillover effects;

2. a deeper understanding of the use of a multi-method design and integrative approach to investigate the research area, focusing on the combination of quantitative and descriptive data to

represent a holistic understanding of the scenario being investigated;

3. a valid and reliable tool for the measurement of crowding experience on public transport, covering descriptive-psychosocial, affective, and ambient components of crowding;

4. a refined and comprehensive model for evaluation of the effects of rail passenger crowding, illustrating relative impact at both individual and organisational levels;

5. a set of recommendations for mitigating rail passenger crowding, focusing on the psychological, non-engineering interventions; and

6. indication of areas of further importance for future research work.

1.7 Chapter summary and conclusions

In this chapter, the background of the research was contextualised and the problem areas were presented. More importantly, this introductory chapter has justified the need for the present work and described the scope of the research, including the research problems being investigated and the research questions to be answered. Having set the scene, the next chapter provides a more systematic and in-depth review of key research and literature that have informed this work and assisted in the further development and refinement of the research questions.

CHAPTER 2 – THE NATURE AND EFFECTS OF RAIL PASSENGER CROWDING: A SYSTEMATIC REVIEW OF THE LITERATURE

2.1 Chapter overview

This chapter presents a systematic review of the literature that summarises and synthesises the existing evidence on the nature of passenger crowding in rail services and their possible impact on commuters' well-being. The systematic review serves to inform the present work of the current state of evidence on this issue and about key gaps in the knowledge that are in need of further scientific exploration.

This chapter begins with a brief discussion of crowding and density as well as a general overview of the mechanisms underlying differential human responses to crowding (Section 2.2 and 2.3). An outline of the conceptual distinction between crowding and density is necessary to provide a basis for subsequent analysis. This is followed by a proposition on why rail passenger crowding is an important issue for research and practice (Section 2.4). Sections 2.5 and 2.6 describe the current investigation and the methodology adopted in conducting this review, while Section 2.7 discusses the findings. Under Section 2.8, the findings are synthesised and discussed in terms of four topics: (1) antecedents of rail passenger crowding, (2) consequences of rail passenger crowding, (3) theoretical accounts of rail passenger crowding and its outcomes, and (4) measures to alleviate rail passenger crowding and its associated outcomes. Section 2.9 discusses the gaps identified in the review and considers the implications of the findings. The chapter concludes with the suggestion that the findings of the systematic review provide a basis for examining the nature and effects of crowding on passengers' experience of stress and possible spillover effects in terms of individual and organisational outcomes.

It should be noted that this chapter focuses primarily upon issues associated with crowding on rail services, and that fundamental theoretical frameworks about crowding are not specifically addressed here. The latter issues are dealt with in the next chapter which presents the theoretical perspectives of crowding and demonstrates how the present work is informed by empirical research in this area. The next chapter also includes the conceptual framework and operational model developed for the current work and the formulation of the research questions and hypotheses that are tested.

2.2 Crowding and density

An exploration of the concept of crowding would be incomplete without some discussion of its relationship to density, personal space, and territoriality. In urban and residential studies, crowding has generally been referred to as the ratio of people to space, which can be objectively conceived in terms of density, such as the number of individuals per given unit of land area or the number of persons per room in a dwelling (Evans, Palsane, Lepore, & Martin, 1989; Fischer, Baldassare, & Ofshe, 1975). It was not until the seminal work of Stokols in 1972 that the distinction between density and crowding was fully recognised.

Density, which is defined as the physical condition of having limited space available for the given number of individuals present, is considered as a necessary but not sufficient condition for crowding, whereas crowding is "a subjective, psychological state in which one's expectation for space exceeds the available supply" (Stokols, 1972a, p. 75). Researchers argue that only when density restricts individuals' movement, interferes with their goals, or intrudes on their personal space and privacy will the environment be perceived as crowded (Evans & Wener, 2007; Eroglu, Machleit, & Barr, 2005). The perception of crowdedness may lead to emotional distress and potentially to some behavioural adjustments as an attempt to preserve one's personal space and regain the control of one's territory which has been threatened. More recent studies have further supported the notion that high-density environments are not necessarily perceived as crowded, and that stress-related physiological, psychological, and behavioural reactions do not necessarily follow from exposure to such environments (Cox et al., 2006; Bell et al., 2001).

2.3 Consequences of crowding

Extensive reviews have reported negative effects of crowding (Bell et al., 2001; Baum & Paulus, 1987). Starting with animal studies, researchers became aware of physiological and behavioural abnormalities such as endocrine malfunction, aggression, and a behavioural sink arising from high-density living (Lorenz, 1966; Calhoun, 1962). The adverse outcomes observed in these animal studies fuelled growing interest in extending the empirical investigation to human communities. However, results from human studies have been inconsistent, with some studies showing various negative outcomes while others fail to find any pathological effects of crowding (Bell et al., 2001; Baum & Paulus, 1987; Freedman, 1975). Those studies which do report significant effects of crowding generally found that crowding, be it in a primary or secondary environment, is linked with three negative consequences: it can (1) induce psychological and physiological stress, (2) contribute to negative health outcomes, and (3) elicit changes in behavioural responses.

First, stress arising from crowding has both psychological and physiological components. A substantial body of literature shows that household crowding leads to strain, annoyance, distress, and sometimes aggression in both adults and children (Evans, Lepore, Shejwal, & Palsane, 1998; Fuller, Edwards, Sermsri, & Vorakitphokatorn, 1993; Gove & Hughes, 1983). Adverse effects are also reported in studies of open-plan offices, where crowding has been found to be associated with increased absenteeism at work, frequent lateness, more intention to transfer, and low work area satisfaction (May, Oldham, & Rathert, 2005; Hedge, 1982; Sundstrom, Burt, & Kamp, 1980). In addition to psychological effects, there are also physiological stress responses resulting from crowding. It is suggested that individuals who are subjected to crowded conditions are likely to experience a rise in heart rate and blood pressure (Bell et al., 2001; Baum & Paulus, 1987) as well as an increase in stress hormones through elevated cortisol or catecholamine levels (Evans & Wener, 2007; Wener, Evans, & Lutin, 2006). Further, crowding has been associated with other forms of physiological arousal such as palmar sweating, increases in skin conductance, high endocrine activity, and greater cardiovascular reactivity (Baum & Paulus, 1987).

Second, research evidence shows that crowding has adverse consequences for health. For instance, studies in residential settings report that individuals living in overcrowded households are more susceptible to illnesses and multiple infections than those living in less crowded ones (Clauson-Kaas et al., 1997; Fleming et al., 1987). Two reasons are offered to explain why crowded conditions may have a detrimental impact on health (Fuller et al., 1993). First, stress associated with crowding can weaken the immune system, which, in turn, may impose other health effects. Cox, Paulus, McCain, & Karlovac (1982) suggest that the physiological responses associated with crowding-induced stress, such as elevated adrenocorticol activity or adrenal medullary activity, are related to the suppression of the immune system and thus account in part for poor health. Not only does a suppression of the immune system result in susceptibility to contagious disease, it may also encourage susceptibility to microorganisms already harboured by the body. It is therefore possible that as a stressor, crowding plays a role in disturbing this balance and leads to physical pathology. Second, close proximity in overcrowded conditions may facilitate the spread of communicable diseases and subsequently increase the risk of infection. Crowding, therefore, has a double impact on health because it makes the individual feel vulnerable due to stress while simultaneously offering greater opportunities for the transmission of diseases.

Third, studies have also highlighted the negative behavioural consequences of crowding. Effects such as a decreased ability to tolerate frustrations (Dooley, 1978; Sherrod, 1974) and increased social withdrawal from involvement and interaction with others (Baum, Harpin, & Valins, 1975) have been observed, especially in competitive settings where many people are present. There is also evidence of disruptive and aggressive behaviour (Loo & Kennelly, 1979; Hutt & Vaizey, 1966) and impaired task performance (Baum & Paulus, 1987) following exposure to crowded conditions. While social withdrawal is associated with large numbers of people present in a setting, disruptive and aggressive responses have been observed in situations characterised by fewer people where reported crowding relates more to spatial restriction or the inappropriate proximity of others (Baum & Paulus, 1987).

Some researchers have also argued that the effects of crowding stress can persist long after the exposure to crowding has ended (Bell et al., 2001; Sundstrom, 1978; Stokols, 1976). After-effects, cumulative effects, and carryover effects are three terms often used interchangeably to describe these phenomena. According to Bell et al. (2001), in the face of continued exposure to stress, a person's adaptive resources are depleted, causing after-effects and a reduction of subsequent coping ability. Stokols (1976) argues that the after-effects differ according to the environment in which the crowding occurs. He explains that crowding experiences in secondary environments such as in public transportation can lead to short-term post-crowding task performance deficit while intensely stressful crowding experiences in primary environments such as at home can have persisting physiological, psychological, and behavioural consequences.

There exist several forms of after-effects that are documented in the crowding stress literature, with the bulk of evidence coming from laboratory studies. The first of this is the behavioural after-effects which refer to decrements in task performance following exposure to crowding (Bell et al., 2001; Baum & Paulus, 1987). These effects are particularly demonstrated in an experimental study by Evans (1979) who found moderate decrements in complex task performance due to crowding. He also reports that participants who were previously stressed by being crowded performed more poorly on a group cooperation task and showed less tolerance for frustration as an after-effect of the crowding experience.

Post-crowding after-effects may also include interdomain or spillover effects (Evans & Cohen, 2004; White & Rotton, 1998). In general, spillover is a process in which daily life experiences in one domain, including stressors, can transfer or spill over into other life domains. From a few of the available empirical studies, the spillover effects of crowding are found to be associated with a variety of adverse outcomes, including social withdrawal, less altruistic behaviour, reduced levels of interaction, lower frustration, and emotional disorders (Bell et al., 2001; Baum & Paulus, 1987).

It is also likely that post-crowding after-effects may involve diminished coping mechanisms. Reduced coping ability with multiple stressors is found following repeated or prolonged exposure to crowding stress. In their review, Evans and Cohen (2004) report that crowding may reduce subsequent coping efforts in such a way that it can exacerbate the impact of high temperature on negative affect and can heighten the effects of daily hassles on psychological health and physiological stress in high-density homes. When attempts to cope with the experience of crowding stress are unsuccessful or are perceived to have failed, learned helplessness sets in. Studies have shown that individuals who live under crowded living conditions report less perceived control or feelings of mastery over their immediate surroundings while simultaneously exhibiting more withdrawal behaviours and symptoms of helplessness compared to others living under less crowded conditions (Evans & Cohen, 2004; Baum & Paulus, 1987).

In summary, the significant effects of crowding as an environmental stressor that can trigger a variety of outcomes has been reasonably established in the literature. While the direct and cumulative effects of crowding are well documented in a variety of research settings, these effects have received less attention within the transportation research area. With continued passenger growth expected across rail and other public transport operations, it would be equally important to address the question of the role played by crowding in evoking stress and other associated outcomes in this particular setting.

2.4 Rail passenger crowding: Definitions and measurements

Public transport is regarded as a secondary environment where one's encounters with others are relatively transitory, anonymous, and inconsequential (Stokols, 1976). Its users primarily understand that crowding or other forms of negative stressors are faced only temporarily. Passengers, to some extent, anticipate crowded conditions and are even willing to tolerate them in the short term. However, expectations of crowding neither reduce people's perception of crowding nor decrease their level of interpersonal effects and general levels of discomfort (Baum & Greenberg, 1975).

The impact of rail crowding on the commuting experience or satisfaction has been measured typically only as a small part in studies of commuting stress (for example, Thomas, Rhind, & Robinson, 2006; Cassidy, 1992). Crowding is often identified as one of the factors that can lead to the experience of strain in passengers, but it appears that few extensive efforts have been made to investigate the entirety of its process. The theoretical basis for such study is arguably weak due to the inconclusive evidence collected in railway risk assessment exercises. For example, Turner et al. (2004) and Woods (2005) report that risks associated with crowding are statistically low compared to risks from other non-crowding related hazards on the railway. According to them, the lack of evidence may be partly due to the fact that rail transport safety cases only need to present the significant findings of the risk assessment, and crowding may not be significant when compared with other hazards. Nevertheless, the studies do point out that the perception of risk from crowding appears higher among the public and rail users and is a major issue for their health and safety.

Another reason why rail crowding remains an under-researched area is probably related to the lack of a precise definition of crowding for use in the public transportation context, which, in turn, leads to difficulties in measurement. There is some debate and inconsistency concerning the definition and interpretation of rail crowding among researchers, industry players, rail authorities, and users (Davis Associates, 2008; Woods, 2005; Turner et al., 2004). For example, in a comprehensive study investigating crowding as a contributory factor to health and safety where various key-stakeholders were consulted, Turner et al. (2004) found that rail-related industries tend to define train overcrowding as situations "where passengers cannot shut the train door" or "where the flow of people is restricted", while rail authorities define overcrowding more broadly as "when there is a potential for harm as a result of the number of people". However, a more explicit definition is offered by the Strategic Rail Authority (2002), who describes train overcrowding as a situation where "there are no spare seats on long journeys or where standing passengers have less than 0.55m² of space each on short journeys".

From the user's perspective, however, most of the typologies offered by these organisations are fairly irrelevant. For them, the most prevalent forms of train overcrowding are characterised by seating availability, standing duration, movement through a crowded train, support structures, and personal space (Davis Associates, 2008). Similar dimensions in terms of personal space for standing passengers and the ability to move about and enter and exit the carriage without difficulty are also observed in the users' definition of acceptable overcrowding (London Assembly Transport Committee, 2009b). It appears that the passengers' definition of crowding covers both an objective definition of density and a subjective definition of perceived crowding. Density is represented by seating and standing space, whereas perceived crowding is characterised by restrictions to movement, lack of support structures, and invasion of personal space (Davis Associates, 2008). In light of these studies, it is evident that defining rail crowding is complex and is based on a mixture of standards.

Up to this point, the literature seems to suggest that rail crowding is defined more often as a quantitative and objectively measurable experience. Two broad measures that are employed to determine crowding level primarily involve measurements of passenger density and train capacity. Passenger density is usually determined by calculating the average number of passengers per unit area on station platforms or onboard a train, expressed as passengers per square metre or foot (Fritz, 1983), while train capacity is generally defined as the estimation of the maximum number of passengers that can be carried in one hour, in one direction on a single track (Parkinson & Fisher, 1996). Seating capacity and standing capacity are among the variations that have been used to measure passenger density. One example of this variation is the crowding measures currently used by the London Underground, which calculate the percentage chance of being on a train with (i) all seats full; (ii) one person standing for every person sitting; and (iii) two persons standing for every person sitting (Dodgson, Kelso, Van der Veer, Skene, & Parades, 2002). Additionally, the UK Rail Safety and Standards Board has developed a measurement tool that uses visual cues of passenger capacity on trains for judging and monitoring crowd density (RSSB, 2004).

Meanwhile, in a series of studies investigating the relationship between crowding and train and station dwelling times, Lam and colleagues (Lam, Cheung, & Lam, 1999; Lam, Cheung, & Poon, 1999) measured passenger loading using five levels of service (LOS) adapted from Fruin’s work (1987) and the Transportation Research Board’s (1985) Highway Capacity Manual. This crowding estimation focuses on the amount of area a passenger is afforded while in the carriage and can be calculated in terms of the number of passengers per seat (for vehicles designed for seated travellers) or floor area per passenger (for vehicles designed to have most people standing). Loading can be located anywhere between the range LOS A (*No passenger needs to sit next to another with more than 1.85m^2 per passenger and 0.00–0.50 passenger per seat*) to LOS F (*Crush loads with less than 0.30m^2 per passenger and more than 3.00 passengers per seat*) (Lam, Cheung, & Lam, 1999; Lam, Cheung, & Poon, 1999). However, LOS for station platform standards are based on the available standing space and the ability to move from one location to another, and their values may range from LOS A (*Large spaces available, free standing and slightly restricted circulation with average pedestrian area occupancy of more than 1.20m^2 per person*) to LOS E (*Very crowded with passengers' personal space equivalent to the approximate area of the body ellipse with average pedestrian area occupancy of less than 0.28m^2 per person*).

Two other objective measures that are employed to measure rail crowding are passengers in excess of capacity (PIXC) and degree of crowding (DOC). PIXC is derived from the proportion of passengers on trains in excess of the seating capacity for longer distance services, with an allowance for standing passengers on shorter journeys of less than 20 minutes (Department for Transport, 2009). The acceptable PIXC limit is 4.5% for one peak (morning or afternoon) and 3.0% across both peaks. The adequacy and accuracy of this measure, however, is relatively debatable for several reasons. For instance, it has been noted that PIXC is calculated across the whole of a train operating company's area rather than on particular routes, it is carried out only once a year, and more importantly, it is not a standard measure across all rail systems (Davis Associates, 2008).

While PIXC measures the degree to which load factor standards are exceeded in practice, DOC relates passenger loading along various percentages of train capacity (Lam, Cheung, & Lam, 1999; Lam, Cheung, & Poon, 1999). The percentage may range from DOC 1 (*25% of train capacity with some seats available*) to DOC 5 (*120% of train capacity where very crowded with passengers inside the car and passengers are forced to press against the windows and doors*). It is also worth noting that parameters based on the number of passengers per square metre and the amount of standing space available for each passenger are also used to evaluate crowding, as they may provide an alternative measurement of discomfort (Wardman & Whelan, 2010; Dodgson et al., 2002).

Psychological studies attempting to investigate crowding on trains are also primarily focused on measuring perceived crowding using density or spatial measures (for example, Evans & Wener, 2007; Wener & Evans, 2004; among others). In these studies, crowding experiences have typically been assessed using self-rating techniques that involved asking participants to rate levels of density inside the trains (for example, Evans & Wener, 2007; Buckley & O'Regan, 2004; Wener & Evans, 2004; Costa, Pickup, & DiMartino, 1988; Singer, Lundberg, & Frankenhauser, 1978; Lundberg, 1976). Of these studies, only two outline their crowding indices in detail (Evans & Wener, 2007; Wener & Evans, 2004); the remaining studies just mention briefly that their participants were asked to rate levels of density and perceived crowding. Nonetheless, it is apparent from this limited literature that the ratings of density level are used in defining subjective measures of crowding.

The problem of using density and crowding as interchangeable terms and the lack of a precise definition and measurement of rail passenger crowding leads reasonably to difficulties in obtaining an accurate understanding of the phenomenon. Cox et al. (2006) argue that while the objective definitions of rail crowding based solely on spatial factors may seem to serve the purposes of rail authorities and train operating companies, these definitions remain inconclusive, particularly when examining individual, subjective perceptions of crowdedness. Although there are earlier studies of crowding on trains (for example, Singer et al., 1978; Lundberg, 1976), only recently have studies acknowledged the role that non-spatial factors such as duration, predictability, and perceived control can have in rail passenger crowding (for example, Evans & Wener, 2006; McLennan & Bennetts, 2003; Wener et al., 2003; Evans et al., 2002). However, even in these studies, a great deal of attention is given to duration, control, and predictability as covariates for commuting stress instead of crowding, the effects of which remain unclear. In light of this need, Turner et al. (2004) propose that any attempt to investigate and conceptualise rail crowding should encompass two components of crowding: (1) density and the available space, which represent the objective components; and (2) perception of both the available space in the physical condition and the number of people present, which characterise the subjective elements. A comprehensive measure based on both subjective and objective elements of crowding is thus warranted.

Rail passenger crowding has been, in essence, inadequately defined and conceptualised in the literature. Beyond passenger density and train capacity, only modest consideration has been given to investigating the subjective experience of crowding, which may also contribute to passengers' experience of stress, and possibly, spillover effects. Rail passenger crowding has also been regarded as too complex to be measured, as it is subjective and multi-faceted. The measurement of perceived crowding itself is difficult, which leads to difficulties in the measurement of rail passenger crowding. Furthermore, although a sizeable amount of research into crowding on public transportation has emerged, there is a lack of attempt to systematically synthesise the findings across these studies to explore the extent to which rail crowding influences passengers' well-being and their overall commuting experience. Based on these observations, this review therefore seeks to identify and synthesise studies that have investigated the nature and potential consequences of rail passenger crowding.

2.5 The current investigation

One way to examine the wider impact of rail passenger crowding is to establish how and to what extent the perceptions of and reactions to crowding interact. As noted by the UK Rail Safety and Standards Board, understanding the causes, effects, and solutions of the rail passenger crowding problem is important (Turner et al., 2004). However, at present, no systematic review has been conducted that summarises the available evidence for an association between rail passenger crowding and its adverse outcomes. Moreover, a systematic integration and consolidation of the literature is warranted in order to inform policymakers, train operating companies or rail operators, professional transport groups, and researchers about the current state of evidence on this issue and about key gaps in the knowledge that are in need of further scientific exploration. This chapter reviews and critically evaluates current research into crowding, with particular concern for its implications for rail users. In studying this literature, our particular focus is on examining the research evidence regarding the determinants of rail passenger crowding, its impact on rail passengers, and its association with passenger stress and overall commuting experience.

2.6 Method

2.6.1 Objectives

A systematic review of the literature, which broadly focuses on the question of the relationships between crowding and its effects on passengers' experience of stress and possible spillover effects, was conducted. The specific questions that the review addresses are: What is the nature of the research into rail passenger crowding? What relevance does it have to understanding passenger stress, well-being, and overall commuting experience?

2.6.2 Search strategy and study selection

A broad and inclusive search protocol, which followed the Cochrane Collaboration's (Higgins & Green, 2011) and Cooper's (2003) guidelines, was applied to identify all relevant studies. To ensure an exhaustive search across all resources, a wide range of synonyms and complex search strings of concepts such as rail passengers, crowding, stress, exhaustion, well-being, and spillover were used. The keywords searched and the criteria of the evidence considered in addressing the research question were determined using recommendations by Petticrew and Roberts (2006). The keywords were then searched in the titles, abstracts, subject headings, and in the full texts of each of the selected resources.

The selection criteria for inclusion in the review were: (1) the study examines crowding and the psychological processes related to it; (2) crowding experiences are investigated in relation to stress, exhaustion, well-being, or spillover outcomes in their broadest sense; and (3) the study focuses specifically on exploring the impact of crowding in rail passenger transport. Studies were excluded if crowding was not investigated in relation to human studies, the study did not examine crowding outcomes specified on rail or train services, or the study was not published in English.

Thirteen premier resources for bibliographic and abstract coverage for original and review articles, conference proceedings and technical reports as well as book chapters and dissertations were searched, including the Cochrane Reviews, PsycARTICLES, ScienceDirect: Elsevier, EBSCO HOST, Wiley InterScience, Emerald, British Library Public Catalogue, ProQuest Digital Dissertations, ISI Proceedings, Zetoc, Intute, TRIS Online, and NLM Gateway (see Appendix A for a full description of the list). These databases were chosen because they provide comprehensive coverage of both refereed and non-refereed social, psychological, medical, and technological research involving crowding and transportation. Studies published from as early as 1823 until 2011 were eligible for inclusion. Subsequent related studies were identified in two ways: (1) reference tracking, where the reference list of all included studies were examined; and (2) citation tracking using Web of Science Citation Index and Scopus databases, where studies that subsequently cite the included studies were identified. Figure 2.1 presents the flowchart of the selection of eligible studies.

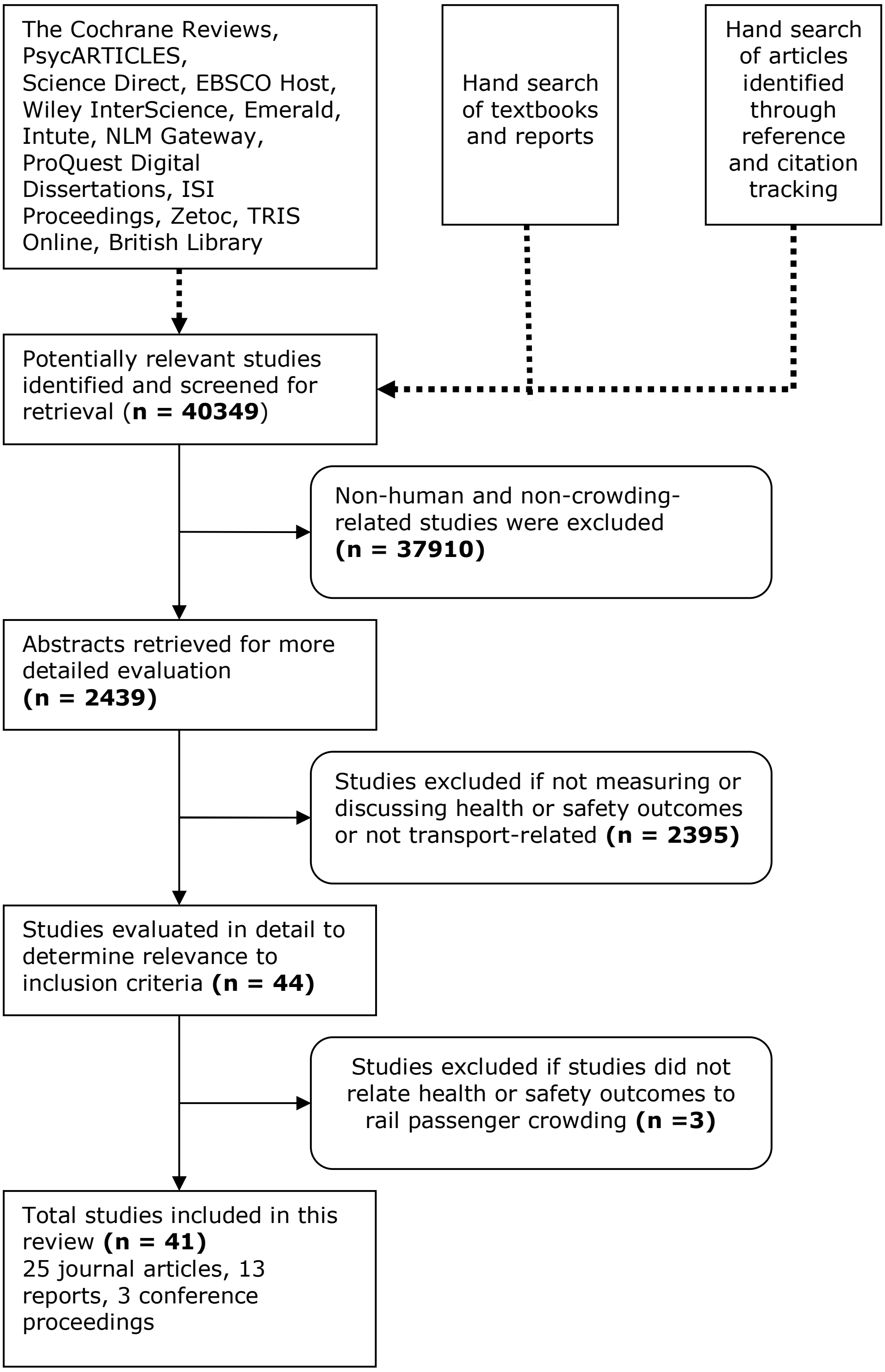

Figure 2.1. Flowchart of selection of eligible studies.

2.6.3 *Review process*

Study screening and selection decisions were performed independently by the researcher and checked by the supervisors. Papers that met the inclusion criteria for possible inclusion in the review were retrieved in full. Information such as study characteristics, study designs, analyses, and key findings were then extracted from these papers. Next, each of the included studies was critically appraised for usefulness in answering the review question.

As the included studies were heterogeneous with respect to study design, focus of research area, and outcome measures, a statistical synthesis of their findings would be considered inappropriate and invalid. A more suitable method for such a diversity of studies is a systematic review that analyses the studies narratively, followed by an attempt to form unbiased conclusions (Lucas, Baird, Arai, Law, & Roberts, 2007; Dixon-Woods, Agarwal, Jones, Young, & Sutton, 2005). This methodology is considered as one of the alternatives to a full systematic review, as it involves a systematic literature search and a predetermined data extraction procedure (Petticrew & Roberts, 2006). Accordingly, the relationships among the key findings of the included studies in this review were thematically explored and summarised using a narrative approach.

2.7 Results

The initial screening of the studies identified 2439 articles which were considered to be relevant to the aims of the review. After some further refinements in the selection process, only 41 studies met the inclusion criteria and formed the basis of this review. Of these eligible studies, 25 were journal articles, 13 were reports, and three were published conference proceedings. The studies eligible for inclusion in this review, which are marked with an asterisk in the References section, varied in terms of their research methods (from literature reviews and archival data to surveys and experiments), data collection (from quantitative to qualitative data), sample size (from N = 17 to N = 1994), and the country in which they were conducted (from the United Kingdom, North America, Europe, to Hong Kong).

The majority of the studies were descriptive, non-experimental, and cross-sectional. In only two studies were data collected from laboratory experiments, while three studies used a quasi-experimental design for their data collection. In 12 studies, data were collected from cross-sectional surveys using interviewer-administered, postal, or online questionnaires, whereas a descriptive design was adopted in another 11 studies. It is also interesting to note that mixed-method approaches and mathematical models were employed in ten and three studies respectively. In six studies, objective measures of stress such as salivary cortisol levels and catecholamine excretions were collected in addition to the subjective measures of perceived stress. A variety of data analysis techniques is used in these studies ranging from regression analysis, multi-factorial analysis of variance, generalised linear model, and logit analysis to narrative review and thematic analysis. Three of the studies use simulation or mathematical modelling to explain their findings, while ten studies use a mixed-method design where descriptive statistics are presented. Most reports, however, use archival data extracted from the literature or case studies and written and oral evidence in their discussion. A summary of included studies is given in Appendix B.

2.8 Synthesis of findings

In order to draw evidence-based implications for the nature and effects of rail passenger crowding, the findings were synthesised into four themes: (1) antecedents of rail passenger crowding, (2) consequences of rail passenger crowding, (3) theoretical accounts of rail passenger crowding and its outcomes, and (4) measures to alleviate rail passenger crowding and its associated outcomes.

2.8.1 Antecedents of rail passenger crowding

Factors that contribute to rail passenger crowding are reported in three studies. In a study investigating the peak-period commuting pattern, Tian, Huang, and Yang (2007) found that heavy demands at peak hours and preferred departure times contribute to crowding build-up. More specifically, they found that commuters who live nearer to their workplace always ride the train together with those living further away, and that the train arriving at the time desired by everyone is utilised by commuters from all stations, which then leads to crowding on the train and at the station. Lam, Cheung, and Lam (1999), however, report that the localisation of passengers at particular areas such as near the ticket vending machine creates a bottleneck that impedes passenger movement within the stations. While these studies highlight the spatial aspect of crowding, a study by Evans and Wener (2007) explains that passengers feel crowded because they feel that their personal space or privacy has been invaded by the close presence of others. The emphasis on the psychological or non-spatial aspect of crowding in this study is important because it provides further evidence that there are two distinguishable dimensions contained within the larger rail passenger crowding definition.

2.8.2 *The effects of rail passenger crowding*

Thirteen studies highlight the health and safety hazards associated with railways (Cheng, 2010; London Assembly Transport Committee, 2009a; London Assembly Transport Committee, 2009b; Cantwell et al., 2009; Davis Associates, 2008; Thomas et al., 2006; Passenger Focus, 2006; Gershon et al., 2005; Weyman, O'Hara, & Jackson, 2005; Turner et al., 2004; Cox, Griffiths, & Houdmont, 2003; Cox, Lotinga, Houdmont, & Griffiths, 2002; Lerer & Matzopolous, 1996). Specific hazards identified in relation to platform and on-train crowding include accidents due to congested pathways or constricted platforms and injuries due to crowded stairs, escalators, elevators, ramps, or packed transfer stations. Altogether, it appears that many of the incidents caused by crowding fall into six categories: (1) slip, trip, or fall; (2) caught in the doors; (3) crushing; (4) struck by or against objects; (5) faint or collapse; and (6) strain (Davis Associates, 2008). In the study by Lerer and Matzopolous (1996), overcrowding and risk-taking behaviour are regarded as the main causes of fall-from-train incidents. A similar concern about overcrowding on trains as an emerging threat to health and safety is raised in studies by Cox et al. (2003; 2002). Instead of imposing a direct relationship between crowding and health and safety issues, these authors argue that there is a possibility of an indirect, moderated relationship between the two variables.

Psychological stress responses following rail passenger crowding, which were obtained mostly from self-reporting questionnaires, were reported in seven studies. In a series of research works investigating the effects of commuting in Dublin, Buckley and O'Regan (2004) and Cantwell et al. (2009) found that public transport commuters, especially rail users, have higher levels of commuting stress, which is attributed to insufficient train capacity and crowded conditions, compared to other commuters. Similarly, studies by Costa et al. (1988), London Assembly Transport Committee (2009b), and Cox et al. (2006) report that public transport users suffer discomfort, stress, and frustration as a result of overcrowding. Meanwhile, the study by Thomas et al. (2006) identifies crowding as one of the main safety concerns among rail passengers, and the findings of Cheng (2010) support this assertion with empirical evidence showing that crowding causes the highest level of passenger anxiety during train travel. Although the psychological stress effects of rail crowding are not directly addressed in another three studies (Wener et al., 2006; McLennan & Bennetts, 2003; Cassidy, 1992), it can be inferred that peak-period journeys involving long commuting time and unpredictable commute can also contribute to increased stress and a more negative mood both at home and at work.

Further evidence of both psychological and physiological stress responses occasioned by rail crowding comes from eight studies. Evans and Wener (2007), for instance, found that physiological stress (measured by salivary cortisol levels), task persistence, and mood are all adversely affected under higher seat densities inside the train. Meanwhile, Lundberg (1976) reports that perceptions of crowding and levels of physiological stress (measured by catecholamine excretion from urine samples) and psychological stress (measured by self-reporting questionnaires on comfort and unpleasantness) increase under conditions of higher passenger density. Similarly, Singer et al. (1978) found that passengers commuting in crowded trains show greater autonomic activity indicative of stress, such as elevated blood pressure and increased epinephrine and cortisol levels. In another five studies, commuting too was found to increase cortisol levels (Evans & Wener, 2006; Evans, Wener, Phillips, 2002; Wener et al., 2005; Wener & Evans, 2004; Wener, Evans, Phillips, & Nadler, 2003). Although these studies do not examine rail crowding specifically, it is assumed that since they were conducted during peak periods, hence "crowded", factors such as the length of the trip, the amount of effort involved, and the predictability of the trip may also affect the perception of crowding and the experience of stress.

Crowding is also associated with some physiological discomfort variables such as heat. In a study where passenger densities were simulated using a whole carriage computational fluid dynamics model, Gilbey, Drake, Lightfoot, and O'Dwyer (2006) found a significant positive association between crowd density and passengers' thermal strain. Additionally, Nicol et al. (1973) report that passengers in ventilated but crowded trains may experience an undesirable and potentially dangerous level of discomfort after 30 minutes, with standing passengers commonly finding these conditions more severe. The study thus recommends that the globe temperature in a carriage should not exceed 30°C in any case, with a physiological limit for safety of 30.6°C

The review has found a limited but somewhat mixed evidence regarding health outcomes associated with rail passenger crowding. On one hand, the study by Costa et al. (1988) found that stressful commuting as a result of overcrowding and other factors leads to more health complaints and greater absenteeism from work due to sickness, while the study by Gershon et al. (2005) highlights the potential transmission of infectious diseases as one of the hazards associated with subways. On the other hand, studies by Turner et al. (2004) and Taylor and Pocock (1972) do not find any significant evidence of adverse health effects of crowding. However, Taylor and Pocock's study (1972) does observe that the incidence of influenza is higher among rail passengers whose journey is most crowded (that is, a loading factor of 70% or more) in comparison to those whose loading is less.

Evidence linking crowding and behavioural outcomes was found in eight studies. Passengers are reported to exhibit a variety of behavioural reactions during crowded or crowd-developing situations ranging from distancing (for example, positioning oneself away from others inside the train to maintain a space and minimise discomfort) and avoidance (for example, avoiding situations where they are likely to be pushed and shoved), to withdrawal (for example, preference for solitude) and aggression (for example, pushing and shoving to get seats) (London Assembly Transport Committee, 2009b; Davis Associates, 2008).

It also appears from the existing evidence that there seems to be limited studies which focus on the after-effects of exposure to rail crowding. In particular, only five studies discuss the after-effects of train overcrowding in terms of its spillover effects. In one such study, Cox et al. (2006) conducted an extensive review of crowding as a possible threat to the healthiness of the rail industry and found that interpersonal stress is likely to have spillover effects in such a way that stressful rail transport services lead to stressed workers, who, in turn, contribute to decreased productivity. Similarly, a report by the UK House of Commons Transport Committee (2003) points to evidence of public transport overcrowding and delays impacting business, causing lateness at work, loss of productivity, sickness absence, missed and rescheduled meetings as well as lost business. The report also argues that public transport crowding can negatively affect the tourism industry. For example, seasonal congestion can discourage tourists and disrupt travel and leisure services, hence contributing to loss of income. Similar spillover effects associated with crowded and stressful journeys are also reported in three other studies, including increased absenteeism and tardiness at work, reduced job satisfaction as well as decreased work performance and work productivity (Passenger Focus, 2006; Cassidy, 1992; Costa et al., 1988).

It is important to note that the review identified six studies that discuss the impact of crowding on overall train performance. More specifically, these studies reveal that crowding affects alighting and boarding rates as well as train dwelling times, causing delayed departures and reduced service frequency, which, in turn, leads to even more overcrowding and limited capacity (London Assembly Transport Committee, 2009b; Passenger Focus, 2006; National Audit Office, 2000; Lam, Cheung, & Lam, 1999; Fritz, 1983). Further, overcrowding is regarded as the most important service attribute for a rail journey (Baker, Myers, & Murphy, 2007), to the extent that rail users are willing to pay more for a less crowded trip (Whelan & Crockett, 2009).

The evidence of the negative outcomes of rail passenger crowding is not without its critics. In a comprehensive study investigating the range of incidents that may involve crowding as a contributory factor to health and safety, Turner et al. (2004) argue that although the perception of risk from crowding appears higher among passengers and other stakeholders, there is little significant evidence to suggest that crowding entails serious health and safety risks. This result parallels the findings from a study by Thomas et al. (2006), who found a weak relationship between the perceived and actual risks of overcrowding on the train or platform. In another study which compared the injuries that were likely to be sustained in an overcrowded train and a non-overcrowded train using data from various rail crashes, Bottomley (1999) maintains that although more people would be injured in the event of a crash involving an overcrowded train, both seated and standing passengers are likely to be injured to an equal degree of severity. The report concludes that there is no evidence suggesting that overcrowding per se is a safety issue in a crash at high speed.

Additionally, the study by Pittard and Jackson (1992), which investigates how overcrowding might affect safety in the event of an emergency evacuation, also found that different levels of loading have little effect on the overall time taken to evacuate a train carriage. The study concludes that location in the vehicle has no effect on the speed at which individuals are able to evacuate the railway coach. Instead, psychological factors such as the individual's willingness to compete with others and their levels of self-consciousness play greater roles in predicting evacuation performance in an overcrowded train.

2.8.3 Theoretical accounts of rail passenger crowding and its outcomes

With the exception of the study by Cox et al. (2006) of a possible linkage between passenger density, perceived crowding, and health and stress-related outcomes and the study by Evans and Wener (2007) of distal and proximal crowding, there are no other studies found in the literature which develop or test their claims against specific theoretical explanations. The former study suggests a moderated relationship between high passenger density, the perception of crowdedness, and the experience of stress in its model of crowding, stress, and health and safety. According to this model, passenger density may lead to perceived crowding, although the relationship is imperfect. Perceived crowding may then drive the experience of stress, which, in turn, may result in a multiplicity of outcomes in both individual and work domains. This model assumes that the impact of high passenger density and the perception of crowding on health and safety-related outcomes is mediated by the experience of stress, and that this overall process is moderated by factors such as perceived control, commute predictability, level of behavioural constraint, level of arousal (activation), and perception of risks. The latter study by Evans and Wener (2007), however, offers an explanation of the role of personal space intrusion that mediates the relationship between crowding and stress. The authors assert that the actual experience of overly close physical proximity to another individual underlies the experience of high-density commuting, and this happens because people feel that their personal space and privacy have been intruded upon by the close presence of others.

Similar factors recommended by Cox et al. (2006) and Evans and Wener (2007) are found in the literature to be important moderating factors. For example, perceived control is demonstrated as one of the moderators between crowding and stress in studies conducted by McLennan and Bennetts (2003), Cassidy (1992), Singer et al. (1978), and Lundberg (1976). Other factors that have been found to moderate a similar relationship include the predictability of rail services (Wener et al., 2006; Evans, Wener, & Phillips, 2002), the duration of rail commuting (Evans & Wener, 2006; Wener et al., 2003; Costa et al., 1988), and using new, improved rail services (Wener et al., 2005; Wener & Evans, 2004; and Wener et al., 2003). Given the consistency of this evidence with the two theoretical explanations proposed by Cox et al. (2006) and Evans and Wener (2007), it seems reasonable to say that both can adequately explain the issue under investigation.

Taken together, this research evidence underlines the need to understand rail passenger crowding by taking into account the important roles of personal space, perceived control, commuting predictability, and commuting duration as possible moderating factors. The research evidence, however, does not directly show that each variable is an underlying mechanism that explains why rail passenger crowding causes reported stress or decreased health. Suffice it to say that in these studies, the four variables are regarded as possible moderating factors only inasmuch as they may impinge on the relationship between rail passenger crowding and its associated outcomes.

2.8.4 Measures to alleviate rail passenger crowding and its associated outcomes

The review discovered that there are at least four categories of measures to alleviate rail passenger crowding and its associated outcomes in the literature. First, individual, psychological measures aimed at coping with crowded conditions and making the rail journey more bearable are found. For example, in a study investigating crowding effects at the Mass Transit Railway stations in Hong Kong, Lam, Cheung, and Lam (1999) found that passengers are willing to travel with an additional travel penalty such as experiencing body contact with other passengers when the in-vehicle travel times are 10 to 20 minutes. Also, crowding conditions on platforms make passengers choose a better level of service even if additional on-platform waiting time is required (Lam, Cheung, & Poon, 1999). It appears from these studies that passengers are coping with crowding by making sacrifices that they would not usually consider – as in this case, losing personal space and a longer waiting time.

Passengers are also found to be more likely to make changes to their commuting patterns and travelling behaviours in order to cope with rail crowding. In a report that investigates passengers' experiences of overcrowding and line closures on the London Underground, the London Assembly Transport Committee (2009b) identified a variety of strategies that passengers use to cope with these situations. These strategies include planning ahead for the journey, avoiding travelling during the rush-hours, deliberately going the wrong way for one or two stops in order to get a seat, and changing commuting habits by walking or cycling. Conversely, passengers are reported to detach themselves from the crowded situation by "switching off" or "shutting down" through activities such as singing to oneself, listening to music, ignoring other passengers, or doing cognitive work such as reading or writing. The report also noted that passengers who have to tolerate relatively crowded trains on a daily basis are likely to view their journey as a series of competitive situations in which they have to engage in a "survival-of-the-fittest" attitude or adopt a "ruthless and selfish tube persona" such as grabbing seats at the expense of pregnant women and people carrying babies. Along with using behavioural coping strategies, cognitive and physiological mental coping strategies are also used to cope with crowding. These strategies include psyching oneself up for the "struggle to clamber on board", changing one's reaction to the journey by ceasing to worry about it, engaging in positive affirmations to replace negative thoughts about the journey, thinking positively and making the most of the commuting situation, and meditating or praying to relax (London Assembly Transport Committee, 2009b).

Second, engineering interventions are often mentioned in the literature. For instance, two studies report the success of engineering intervention in reducing commuter stress and, indirectly, passenger crowding (Wener & Evans, 2004; Wener et al., 2003). The improvement, which involved the introduction of a direct service to particular destinations, significantly reduced the trip time and consequently reduced the commuting stress experienced by the commuters. Another two studies also suggest that overcrowding can be alleviated by interventions such as reviewing the balance of seats and standing space and the provision of first-class coaches, improving timetabling and passenger information, introducing new rail lines, improving train design, providing better information about crowding levels on trains and alternative options for passengers who want to avoid it, and implementing better management of line upgrades (London Assembly Transport Committee, 2009a; 2009b). In general, there is fairly wide agreement that engineering interventions involving additional rolling stock, infrastructure upgrades, network expansion, the introduction of new or alternative transportation modes, simplified fares and ticketing structure, and reliability and service frequency improvements are needed to relieve current train overcrowding issues as well as to allow for future rail expansion (Passenger Focus, 2006; House of Commons Transport Committee, 2003; Dodgson et al., 2002).

While engineering interventions can be expensive, time-consuming, and often involve mandates and regulations, non-engineering intervention strategies focusing on psychological, social, and organisational factors are also potentially feasible for reducing rail passenger crowding. Some examples of non-engineering interventions that have been suggested include re-shaping passengers' expectations of rail travel by educating them to better plan for and cope with their journeys and improving the quality of the overall social and ambient physical environment of the transportation infrastructure (Cox et al., 2003). Also suggested are providing service modifications in terms of the information delivery system for waiting passengers about the levels of crowding on trains and at platforms as well as information about potential alternative routes or modes of transport (London Assembly Transport Committee, 2009a). Staff training in crowd management and crowd control, which may include but is not limited to trainings on the basics of normal and emergency crowd movement and assembly, incident handling, and communications procedures, are also highly recommended (London Assembly Transport Committee, 2009a). Cox et al. (2006) conclude that strategies focusing on psychological, social, and organisational factors, particularly those initiatives targeted at moderating factors between density and perceived crowding, might be more effective than engineering interventions, as they allow rail users to have better control over their journey and ultimately assist them to manage their journey in a less stressful way.

The fourth category of measures for rail crowding mitigation concerns policy measures. These measures, which are proposed in three studies, involve policies such as the setting of a new rolling stock strategy (House of Commons Transport Committee, 2003), increasing the modal shift from rail to other forms of transport (London Assembly Transport Committee, 2009a), and developing a standard procedure for documenting and investigating incidents of crowding-related events and risks as well as implementing good practice approaches in crowd management and crowd control on the railways (Turner et al., 2004). While policy measures are important elements of any crowding reduction strategy, they often require strong political will for their implementation. Furthermore, many policy reforms need a set of long-term strategic frameworks for changing the regulatory, institutional, operational, and physical structures in the overall rail industry.

2.9 Discussion

In this systematic review, we explored the relationship between rail passenger crowding and its consequences, particularly on stress, health, behavioural, and spillover outcomes. The review has provided a thorough discussion of four aspects: (1) the definitions and measurements of train and station crowding, (2) the potential risks and effects of rail passenger crowding, (3) the adequacy of the theoretical frameworks available in the literature, and (4) the strategies adopted for alleviating rail crowding. There has been some progress in the development of rail passenger crowding definitions and measurements, although a universally accepted measure remains unclear. While passenger density continues to be essential in interpreting crowding phenomena, it is not necessarily related to negative psychological states. Intrusion of personal space or privacy, a lack of perceived control, a decreased sense of predictability of the commute, and increased commuting duration have all been found to play important moderating roles in examining the nature and effects of rail passenger crowding.

Although some studies reviewed here argue that the relationship between rail passenger crowding and its associated outcomes might be inconsequential compared to other environmental or situational factors, we found promising evidence in most studies to suggest that rail passenger crowding has a significant and consistent detrimental impact on psychological and physiological stress as well as on health and behavioural outcomes in commuters. These effects incorporate any combination of (1) psychological outcomes, such as stress, frustration, or emotional distress; (2) physiological outcomes, such as elevation of neuroendocrine and autonomic functioning or thermal strain; (3) health outcomes, such as susceptibility to influenza infection; and (4) behavioural outcomes, such as withdrawal, avoidance, or aggression. The review has also found limited but critical evidence of possible spillover effects on organisational behaviour, including job satisfaction, absenteeism, lateness at work, and turnover.

2.9.1 Research gaps identified in the review

There are four gaps in the existing rail passenger crowding research; principally, the majority of the existing studies are cross-sectional and descriptive in nature, which, to some extent, limits the predictive capacity of the findings. Although research evidence at present shows that crowding inflicts individual passengers negatively, we cannot determine precisely how much exposure to crowding is sufficient to produce harm or how much crowding passengers can tolerate, as no study has yet analysed the extent and magnitude of the overcrowding effects. Additionally, where crowding has been explored, researchers have tended to focus on its direct effects and less on its potential spillover effects. It is possible that the experience of stress attributed to crowding can spill over to the work and personal lives of commuters. In contrast to this proposition, relatively little attention has been paid to the role of the experience of stress in this context. These limitations in methodology and knowledge suggest the need for more rigorous investigations to examine the potential direct and spillover effects of rail passenger crowding, with an emphasis on methodologically well-designed research and appropriate analyses that integrate both objective and subjective measurements. It is therefore important for researchers to build on descriptive research with explanatory and predictive approaches that focus more on the underlying reasons and processes which give rise to current crowding stress outcomes.

The review has also identified a measurement gap, in that current measures of crowding using passenger density or train capacity do not tend to capture the full meaning of the crowding construct. Measuring crowding based on single dimension approaches is somewhat limited, particularly when examining individual, subjective perceptions of crowdedness, and fails to capture many of the outcomes that might occur as a result of crowding. As a result, the measures developed so far might be inadequate in tapping the overall dimensions of rail passenger crowding. Arguably, this calls for the need to develop an accurate and reliable scale that can capture the multi-dimensions of perceived crowding for use in the rail passenger context.

While the review highlights the need for methodologically sound research on issues concerning rail passenger crowding, it also reveals a pressing need for establishing a theoretical framework on which future studies can be based so that the effects of crowding can be fully understood. In spite of their attempts to explain a broad range of interactions in the crowding-stress relationship, the two theoretical accounts by Cox et al. (2006) and Evans and Wener (2007) identified in this review are constrained by some methodological limitations, including lack of empirical data validation for the former theory and a small sample size, resulting in limited statistical power in the latter formulation. A refinement of both theoretical accounts would therefore allow a more detailed understanding of the extent of the relationship between rail passenger crowding and its associated outcomes. In addition, a revised model that incorporates significant moderating variables suggested in both theoretical accounts such as personal space, perceived control, commute predictability, and coping strategies would allow more meaningful results to be obtained. These incorporated variables will then lend themselves to empirical estimation and testing, which is the major aim of the thesis.

Finally, it is often assumed that there maybe cultural differences influencing individuals' personal management of crowding, particularly in terms of how individuals deal with or tolerate perceived crowdedness (Pons & Laroche, 2006; Evans, Lepore, & Mata-Allen, 2000; Mandersheid, 1975; Hall, 1966). Nevertheless, the present work found that this issue is not covered in any substantial way in the papers reviewed. In particular, the review did not find any study that examines the influence of culture as one of the contributing factors for the perceptions of and reactions to crowding in the rail setting[1]. Therefore, many challenges in rail passenger crowding research may be noted, at least potentially, in three areas: (1) understanding and measuring its effects on individual psychological well-being, and possibly, on organisational health; (2) examining its place within existing stress and commuting models; and (3) investigating cultural aspects relevant to crowding. The assessment of the experiences of crowding on trains and their associated outcomes is only a first step. It would also be sensible

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[1] Although culture is not the main purpose of the present research, the limited information that is available is being considered separately in another publication.

to assess whether and how crowding can be further mitigated. Identifying potential interventions to reduce rail passenger crowding and its associated impact would therefore provide abundant opportunities for work in this area.

2.9.2 Implications of this review for future research and evaluation in this area

Three practical implications of this systematic review are that it (1) identifies potential factors and theoretical accounts that can help explain why rail crowding imposes stress upon passengers and exposes them to some adverse health outcomes, (2) validates the prior findings on the effects of rail crowding, and (3) reveals potential opportunities for improvements in crowding mitigation initiatives and interventions. Together, this information can provide the rail operators and policymakers with a coherent and forward-looking view of needs and opportunities for crafting the most effective approaches to the current and future rail transport challenges.

The findings of this review also have important policy implications. First, since crowding has a significant adverse impact on passengers' well-being and their overall commuting experience, policies directed at rail health and safety should focus their attention on more important predictors. For example, the current review has identified the need for focusing on the psychological features that enhance passengers' personal space, the interior functionality of a train, and the exterior architecture of a station. Efforts to alleviate crowding and improve passenger comfort and safety, therefore, should be geared towards promoting efficient seating systems, accessible train and station designs, adaptive and reliable scheduling systems, and effective coordination of modes in addition to increasing the amount of rolling stock and the overall capacity of the network. Second, the apparent relationships between commuting factors (such as duration of the journey) and the magnitude of the stress effects suggest that commuting patterns and travel behaviours could be of specific interest to rail management. Policymakers should, therefore, attempt to ease overcrowding conditions by ensuring that rail operators specify an appropriate level of service and enforce adequate measures to reduce overcrowding, backed by punctuality and reliability targets, and penalties for non-compliance (Twigg, 2006).

2.9.3 Limitations of the systematic review

Although this review has attempted to provide a comprehensive account of the nature and extent of rail passenger crowding, it is subjected to two limitations. First, as the review aims to examine the possible effects of crowding on rail services, papers concerning crowding on other modes of transportation such as cars and buses were excluded. Thus, the findings and conclusions that can be drawn are restricted to the rail context. In general, however, the research evidence has pointed to the need for investigating crowding effects and the issue of capacity constraints that result from the increasing demand of public transport usage.

It remains possible that some of the variance in the reported effects may be attributable to the heterogeneity of the research methods and the variable methodological quality of the included studies. Although there have been some experimental studies conducted on this issue, many are qualitative, descriptive, or mixed-method studies that are cross-sectional in nature. Furthermore, the majority of studies reviewed measure stress through different measures of mood, arousal, and stress. The type of rail lines, duration of crowding exposure, and journey distance also varies in different studies, and such non-uniform data might limit the generality and validity of the findings.

2.10 Chapter summary and conclusions

In closing, the systematic review has yielded several important findings that strengthen our current understanding of the nature and effects of rail passenger crowding, and point to some promising new directions for future research. Against this background, evidence of significant associations among rail passenger crowding, the experience of stress, health, behavioural, and spillover outcomes have emerged.

It has been shown that the existing methodology to quantify stress and other associated effects of rail passenger crowding is quite limited and that an alternative, empirical methodology should be considered. Additionally, measurement gaps remain concerning scales, data, and validation of the inconsistent estimates that are being used in the rail industry to assess crowding. In terms of theoretical gaps, there is a lack of a common framework to address emerging issues in rail passenger crowding research. Addressing these gaps calls for (1) a comprehensive research methodology for investigating the nature and effects of crowding in the rail setting, (2) a development of a valid and theoretically-based instrument for measuring the more psychological components of crowding, and (3) an inclusive model for illustrating the relationships between rail passenger crowding and its associated outcomes. Equipped with such, it is possible that the nature and effects of rail passenger crowding can be better understood. The development of such a model and framework is described in the next chapter.

CHAPTER 3 – CONCEPTUAL DEVELOPMENT

3.1 Chapter overview

The previous chapters have provided an overview of our motivation for investigating the nature and effects of rail passenger crowding and highlighted the importance of addressing this issue from research, theory, and practice. This chapter continues with a discussion of the theoretical foundation of the current work. The first three sections assess the advantages and limitations of different conceptual-theoretical perspectives, specifically evaluating the classical and integrative approaches in studying the human response to crowding, as these are the main areas of interest in this thesis. Based on the theoretical approaches discussed, particularly those proposed by Cox et al. (2006), an operational model is developed and explained. The final section of the chapter outlines the five research questions and eleven hypotheses of the thesis and describes the major components of the operational model. Finally, the chapter concludes that a refinement to the Cox et al. model (2006) possesses the potential to address the main gaps in the literature and the capacity to provide a coherent analytical framework for studying the nature and effects of crowding on commuters' experience of stress and possible spillover effects.

This theoretical overview of the issues and concepts related to the human response to crowding is not intended to provide a comprehensive account of all theories and developments in crowding, density, territoriality, personal space, and privacy research. Rather, the most relevant and representative theoretical approaches for the thesis are summarised and critiqued. This provides a basis for the derivation of an operational model for examining the effects of rail passenger crowding on stress and other associated outcomes. Further information on specific theoretical accounts of crowding may be obtained from studies cited in this chapter.

3.2 Classical approaches to the study of crowding

Most of the classical approaches to crowding are univariate, focusing on the physical, social, ecological, and psychological aspects of high-density settings and can be placed into four broad categories. Each of these categories is briefly described and evaluated in the following discussions.

3.2.1 Crowding as a physical phenomenon

One particular theory that considers crowding as a physical phenomenon that can be defined in terms of density or number of people per unit area is the Freedman's (1975) density-intensity theory. This theory proposes that crowding is largely a consequence of limited space availability and maintains that while density by itself has neither good nor bad effects on people, it can potentially intensify the effects of other stressors one may be experiencing. Although the theory is particularly noteworthy for its parsimony and testability (Baum & Paulus, 1987; Edney, 1977), the tendency to examine crowding as a strictly spatial variable is problematic for several reasons. First, the theory uses the terms "high-density" and "crowding" interchangeably, which is fairly inaccurate because the experience of crowding is not solely a function of objective or physical conditions but also involves one's individual perception and evaluation of such conditions (Stokols, 1972a; 1972b). Second, as the theory focuses on the spatial process through which crowding is experienced, it tends to ignore the importance of specific individual, social, or situational conditions that may also contribute to reactions to high-density conditions. Further, researchers such as Rusbult (1979) argue that the density-intensity model does not make implicit the meaning of intensification. For example, does "intensify" mean that one's normal response is increased or decreased? These three drawbacks thus tend to limit the usefulness of the theory.

3.2.2 Crowding as a social phenomenon

When crowding is regarded as a social phenomenon, it essentially relates to the effects of density on the regulation of social interaction. According to this perspective, high-density environments can contribute to crowding and affect interaction in three ways. First, crowding is experienced when the amount and rate of stimulation and social contact present in high-density settings exceed the individual's ability to deal with them (Desor, 1972). Excessive stimulation, which may originate from the number of people or the number of interactions or spatial constraints, can be taxing on humans and would lead to attempts to reduce the level of stimulation by means of withdrawing and decreasing stimulation intensity or by filtering inputs, among others.

Second, the behavioural constraint models propose that crowding occurs when high-density conditions impose restrictions on behaviour or intrude on one's personal space. Prohansky, Ittleson, and Rivlin (1970) as well as Stokols (1972a; 1972b) assert that individuals presented with an environment that does not enable them to have the space or privacy that they desire will experience crowding. The perceived loss of behavioural freedom or the violated personal space can then lead to frustration, negative affect, and stress. These models also predict that individuals experiencing crowding and its associated outcomes will inevitably adapt by withdrawing social interaction or behaving aggressively in order to regain freedom of behavioural choice.

Third, Schopler and Stockdale (1977) suggest that crowding occurs when individuals perceive that the presence of others in a high-density environment interferes with their behavioural goals or desired activities. Although physical density is viewed as a necessary antecedent for crowding, it is the interference attributed to the presence of others that determines crowding stress.

Of all the models discussed thus far, the conceptualisation of the behavioural interference model is perhaps the most comprehensive, as it specifies the conditions under which density will lead to crowding stress, identifies factors such as controllability and personality variables which intensify stress and interference, and discusses the nature and effects of coping (Rusbult, 1979). However, despite receiving some empirical support for the applicability and usefulness of its theoretical framework (for example, Baum & Paulus, 1987; Saegert, 1978), the overload approaches are neither able to clearly define excessive stimulation nor explain the conditions under which stimulation will be viewed as excessive (Rusbult, 1979). Further, they do not clearly specify which way a person will react to high density and how the adaptation mechanisms operate (Baum & Paulus, 1987). Similarly, the behavioural constraint models are limited in two important respects. They do not specify conditions that can be regarded as constraining, nor do they deliberate over which environmental factors are most important in leading to the experience of crowding stress (Rusbult, 1979; Saegert, 1978).

3.2.3 Crowding as an ecological phenomenon

Wicker (1973) underscores the idea that crowding should be understood as an ecological phenomenon. His overmanning theory argues that crowding is experienced when there is a greater scarcity of social roles or resources in a particular behavioural setting.

Overmanned settings, in which the number of individuals exceeds the number of available roles and resources, can exert pressure on individuals and impose various negative consequences. From this perspective, the degree of manning and the type of activity in a behaviour setting are deemed to be more important than density and space in determining whether or not the area is perceived as crowded. On the basis of this assumption, the theory suggests that problems associated with crowding can be alleviated by changing the activity or definition of the situation. Researchers argue that although the overmanning theory may be applied to structured environments such as in residential or workplace settings, it is relatively unsuitable for less structured settings such as crowded trains or congested roads (Bechtel, 1979; Rusbult, 1979).

3.2.4 Crowding as a psychological phenomenon

By implication, perhaps the most prevalent theoretical explanations of crowding are those of the experiential or perceptual state of crowding. According to this perspective, crowding exists only when we perceive it, and since perceptions are usually influenced by a number of external and internal factors such as personal, cultural, social, physical, psychological, and other variables, the ways in which the individuals perceive crowding can be different in many ways (Bechtel, 1979).

Crowding has been described in three ways under this perspective. First, Stokols (1972b) characterises crowding as a motivational state, involving personal and subjective experience that is based on an appraisal of density and other factors. He argues that the experience of crowding often results in "goal-directed behaviours directed toward relieving discomfort or achieving some goal in order to minimise the inconveniences imposed by spatial limitation" (p. 276). The second explanation is offered by Esser (1971), who describes crowding as a “mental state in which stimuli are experienced as inappropriate and stressful” (p. 2). According to this theory, the amount of space or number of people need not necessarily be important in generating feelings of crowding. Instead, feelings of crowding are, in part, a result of discrepancies between central nervous system functioning and stimulus conditions. Individuals will feel crowded if their environment “cannot be completely experienced due to perceptual overload or does not consensually validate their expectations” (Esser, 1973, p. 210). Third, Choi, Mirjafari, and Weaver (1976) argue that crowding involves two types of experiential states which result from the interaction of high density with other social, personal, and physical-environmental variables. The cognitive state refers to the state in which the crowded individual merely perceives the density of a setting without experiencing emotional or physiological changes, while the cognitive-affective-physiological state refers to the state in which an individual perceives crowding with the experience of emotional or physiological changes. The authors argue that the perception and appraisal of crowding can be individually, culturally, or situationally dependent. For instance, people may feel crowded in a room surrounded by strangers but are more comfortable being in the same room with their friends.

In principle, the psychological perspective is most favourable, as it could give a more accurate picture of how individuals explain their crowding experience. Furthermore, this approach provides useful information about how different density situations are perceived by different people as a function of a variety of intervening variables (Bechtel, 1979). One drawback of the theoretical formulations under this approach, however, is that they have viewed crowding too often as a state and not often enough as a dynamic process. Further drawbacks arise from the fact that these formulations are inherently unable to give an adequate description of potential crowding effects and coping strategies (Baum & Paulus, 1987).

3.3 Integrative models of the human response to crowding

During the period when the classical theories of crowding predominated, many scientific discoveries were made, providing a better understanding of the spatial and social aspects of density and the psychological and behavioural reactions from crowded settings. Nonetheless, researchers also realised that the explanation for the perception of and reaction to crowding requires a more process-oriented rather than state-oriented approach in order to provide clearer specification of the antecedents, mechanisms, and consequences of crowding. In their review, Baum and Paulus (1987) argue that the classical models are relatively one-dimensional, focusing largely on the stimulus aspects of density and are discrepant in their response focus and postulation of mediating variables. They further assert that while explaining crowding effects by a singular construct (that is, density) may be parsimonious, the unique issues surrounding crowding as a perceptual and experiential state may be lost.

Due to these shortcomings, theorists began integrating the major elements of the differing classical approaches by exploring the complementary roles of situational, social, personal, and modifying factors in the process of the human response to crowding. Based on the outcome of these studies, researchers postulate that crowding is a multi-dimensional experience that involves personal, psychological, physiological, and social components. The emergent theories can be considered as integrative models of crowding and predominate the current view of the human response to crowding.

The integrative models of crowding have five distinctive features that set them apart from the earlier theoretical perspectives. In general, they (1) recognise crowding as both a physical state of lacking space and a psychological state resulting from the perception of too many people or too little space; (2) conceptualise crowding as a dynamic process whose nature and mechanisms are shaped by the combined contributions of physical, social, situational, personal, and modifying factors; (3) view crowding as a negative and stressful phenomenon that automatically leads to various coping responses; (4) regard individuals as active, purposeful agents who may adopt various coping mechanisms in response to problems; and (5) include feedback loops that provide information on further regulation of the crowding process and its cumulative outcomes. There are five integrative models of interest for this thesis; each model is described and critiqued in the ensuing discussion.

3.3.1 Equilibrium model of the human response to crowding (Stokols, 1972a; 1972b)

Stokols (1972a; 1972b) developed an equilibrium model which regards the experience of crowding as a "perceptual or experiential state that occurs when the individual's demand for space exceeds the available supply" (1972a, p. 75). The model shows that the developmental pattern and intensity of crowding perception are influenced by three interactive factors: (1) qualities of the physical environment, such as the amount and arrangement of space and presence of other physical stressors; (2) the social environment, such as status definition, allocation of power, social interference, and division of labour; and (3) personal dispositions, which may include momentary states, skills and weaknesses, and personality traits (see Figure 3.1). The interaction of these factors with density may lead to the perception of crowding and produce the experience of stress, as manifested by psychological changes, particularly in terms of emotional imbalance and cognitive inconsistency, or physiological stress, such as a rise in blood pressure or hormonal secretion in individuals. As a consequence of the stress experienced, individuals engage in behavioural, perceptual, or cognitive adjustment that may have a variety of adaptive or maladaptive consequences which can also feed changes back into physical, social, and individual factors.

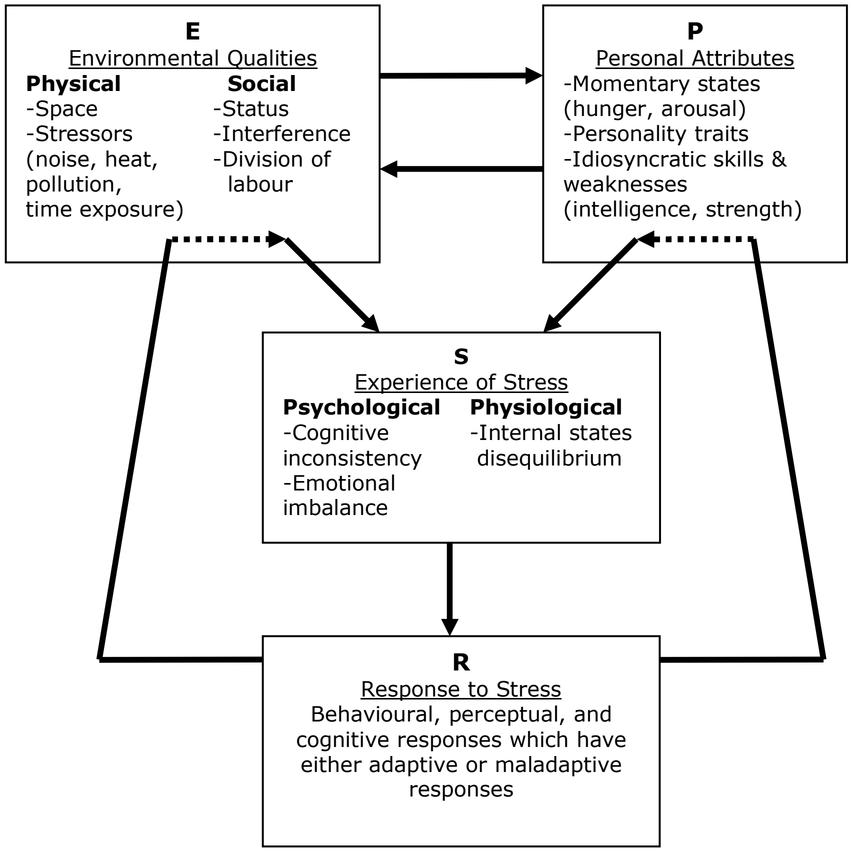

Figure 3.1. Equilibrium model of the human response to crowding. Adapted from "A social-psychological model of human crowding phenomena" by Stokols, D., 1972a, *Journal of the American Planning Association*, 38 (2), p. 77.

Stokols's model represents a comprehensive integration of various factors that characterise the extant crowding literature. However, researchers have criticised the model, arguing that it (1) fails to suggest which variables are most important in leading to the experience of crowding stress; (2) does not adequately explain how the coping process operates; and (3) tends to ignore socio-demographical factors like culture, socioeconomic status, age, previous experience, and local norms, which could set the equilibrium level around which the model operates (Rusbult, 1979; Edney, 1977). Other criticism of this model includes questioning whether it is conceptually appropriate to use the notions of the sensations of crowding, the perception of crowding, and the experiential state of crowding interchangeably. Choi et al. (1976) argue that differential conceptualisations are needed because these notions represent three different psychological states.

3.3.2 Crowding and privacy regulation model (Altman, 1975; 1976)

While Stokols's model describes crowding as a state of psychological stress that occurs when the demand for space in a specific situation exceeds the available supply, Altman (1976; 1975) theorises crowding as a social condition resulting from a lack of privacy. Privacy, for Altman, is a "dialectic and dynamic boundary regulation process involving selective control of access to self or to one's group" (1975, p. 10). Figure 3.2 presents his privacy regulation model.

Altman argues that density per se is not a necessary variable for crowding. Rather, the individual's privacy expectations resulting from personal, situational, interpersonal, and environmental factors are important. More specifically, he suggests that individuals feel crowded when they cannot achieve the amount of privacy desired, which, in turn, leads to stress and arousal. The level of stress, which is determined by the degree of mismatch between desired and achieved privacy, is directly related to costs or outcomes, which can be physical, psychological, or physiological in nature. In addition to the costs experienced, violations of the privacy expectations can also lead to coping behaviours intended to regulate back one's boundary process.

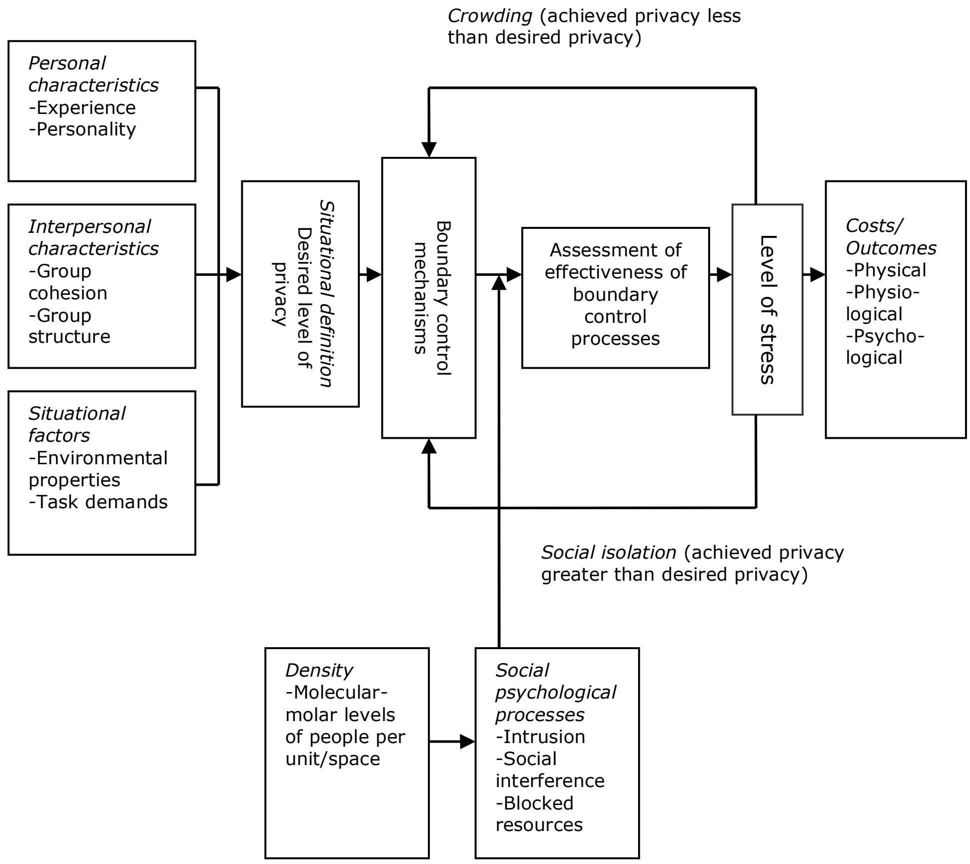

Figure 3.2. Crowding and privacy regulation model. Adapted from "Crowding: Meaning, theory, and methods" by Altman, I., 1975, *Environment and social behavior: Privacy, personal space, territory and crowding*, p. 155.

Although the strength of this model lies in its integrative nature, researchers believe that it fails to explain adequately how the individual comes to hold a particular ideal of desired privacy, does not explain individual differences in privacy ideals, and does not suggest how the privacy ideal may change across situations (Rusbult, 1979).

3.3.3 Crowding as a sequential process (Sundstrom, 1978)

Sundstrom (1978) refines Altman's model by introducing modifying factors such as degree of exposure, type of activity, primary or secondary environment, and desire for contact into the overall framework of crowding stress (see Figure 3.3). According to this model, crowding may be seen as a sequential process in which physical, situational, interpersonal, and modifying factors interact to produce the experience of crowding and associated stress effects, which then necessitate the performance of coping behaviours. The resulting process of coping and adaptation may then contribute to negative after-effects or cumulative effects.

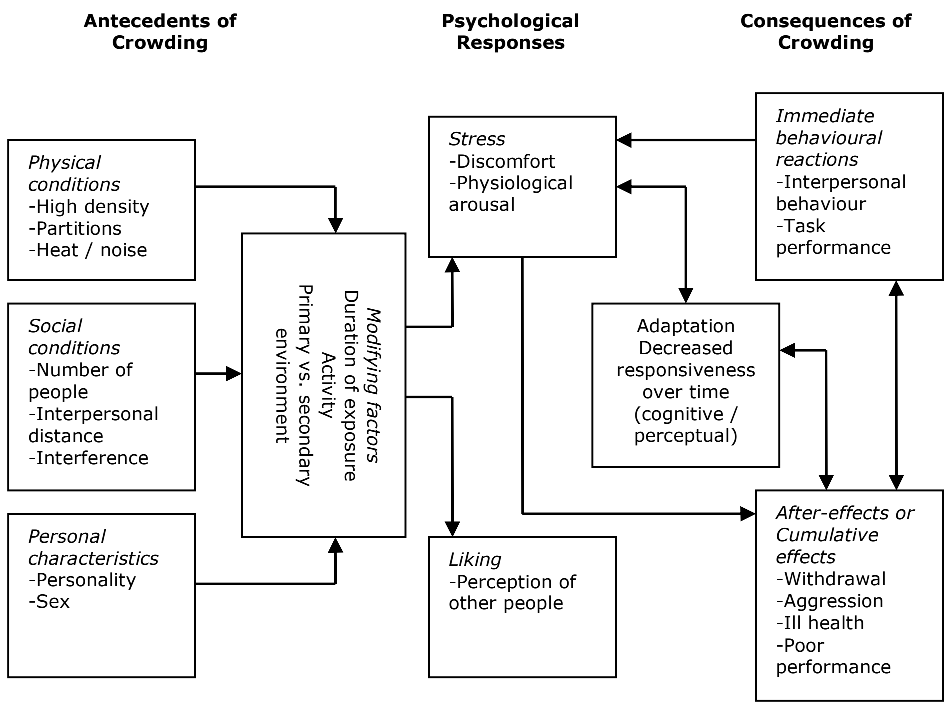

Figure 3.3. Crowding as a sequential process. Adapted from "Crowding as a sequential process: Review of research on the effects of population density on humans" by Sundstrom, E., 1978, *Human responses to crowding*, p. 36.

The distinctive aspect of Sundstrom's approach is that he acknowledges the roles played by the interpersonal conditions such as interpersonal distance and interference, the individual characteristics such as gender and personality, and the modifying factors such as the duration of exposure, apart from those roles played by the physical conditions and density in the appraisal of crowding. In addition, the model looks at the consequences of crowding from three perspectives: (1) the individual's psychological responses to stress, such as adaptation and altered attitudes toward other people; (2) the immediate behavioural reactions, such as changes in performance of tasks and interpersonal coping strategies; and (3) the after-effects and cumulative effects, which include health, withdrawal, avoidance of interaction, or aggression that occur after crowding.

Despite its appeal, the model has two limitations. It is argued that the model is too linear to describe processes that are often non-linear and very complex. Baum and Paulus (1987) assert that many of the predicted processes within crowding-related processes may occur in parallel rather than in sequential mode. The researchers further argue that although Sundstrom's model recognises the adaptation or decreased responsiveness effect due to crowding, it does not provide definitive suggestions for the nature of this effect.

3.3.4 Eclectic-behaviour model (Bell et al., 2001)

Another integrative model is that of Bell et al. (2001), in which they formulated an eclectic model of crowding stress, drawn from the preceding models as well as from stress theories (see Figure 3.4). The model specifies that high-density conditions combined with social, situational, and individual factors can account for the higher perception of crowding. Perceived crowding will then lead to an increased stress state, various coping responses, and possible after-effects and cumulative effects.

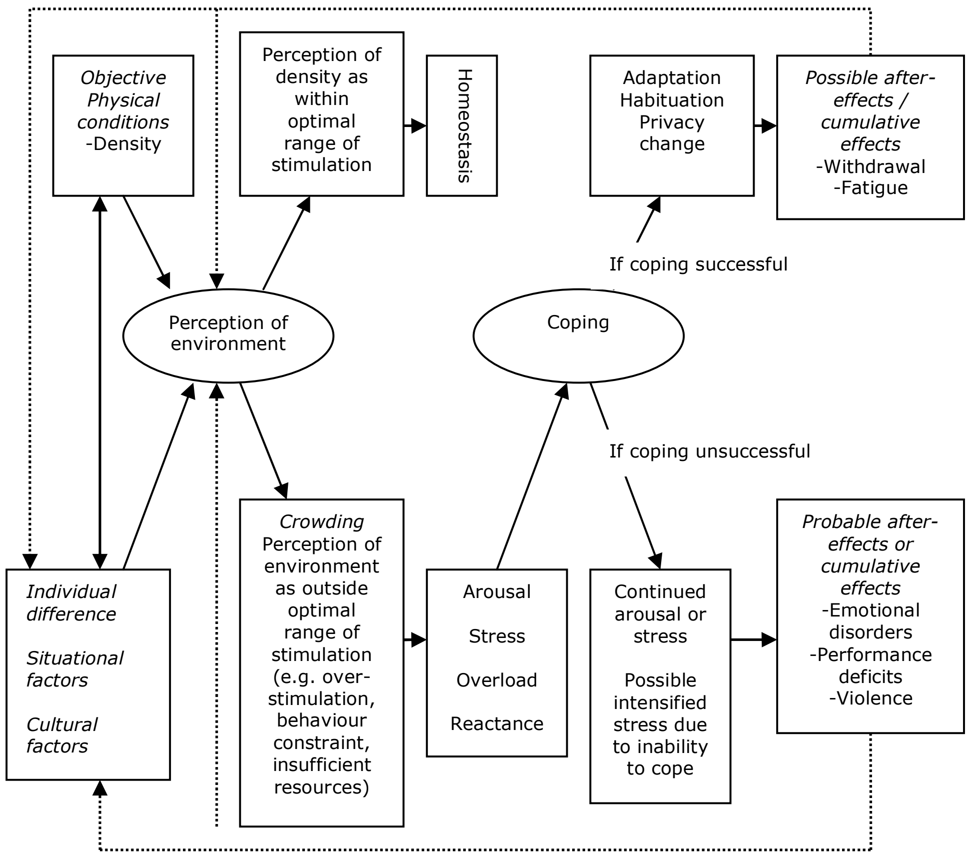

Figure 3.4. Eclectic-behaviour model. Adapted from "High density and crowding" by Bell, P., Green, T., Fisher, J., & Baum, A., 2001, *Environmental Psychology*, p. 320-321.

While the authors agree that high density is a physical state involving potential inconveniences (for example, loss of control, stimulus overload, lack of behavioural freedom, resources, or privacy), they believe that it is the interplay among the individual differences (for example, gender, personality, age), situational conditions (for example, time in the setting, presence of other stressors), and social conditions (for example, relationships between people, intensity of the interaction) that determine whether these factors are significant and whether crowding occurs. If the negative aspects of high density are not salient, then the environment is perceived as being within an optimal range and no crowding occurs. Alternatively, if the negative aspects of high density are significant, then crowding occurs.

Crowding, therefore, is viewed as a “psychological state characterised by stress and having motivational properties that result in attempts to cope with crowding or to reduce the associated discomfort” (Bell et al., 2001, p. 320). When coping attempts are successful, equilibrium would be maintained and after-effects or cumulative effects would be less pronounced. In contrast, when coping attempts are unsuccessful or inadequate in relation to the extent of the stress experienced, the individual is most likely to experience after-effects such as illness, performance deficits, withdrawal, emotional disorders, or violence.

3.3.5 Model of crowding, stress, health, and safety (Cox et al., 2006)

The previous integrative approaches tend to complement one another because they focus on the different aspects of density and crowding. A comprehensive perspective of crowding would therefore involve combining the main elements of each approach. One theoretical approach that has great integrative potential and that is suitable for the focus of the thesis is the crowding, stress, health, and safety model proposed by Cox et al. (2006). This model, which has been identified in the systematic review (Section 2.8.3, Chapter 2), combines the elements obtained from the preceding classical and integrative approaches and is applied to the rail setting. Figure 3.5 presents this model.

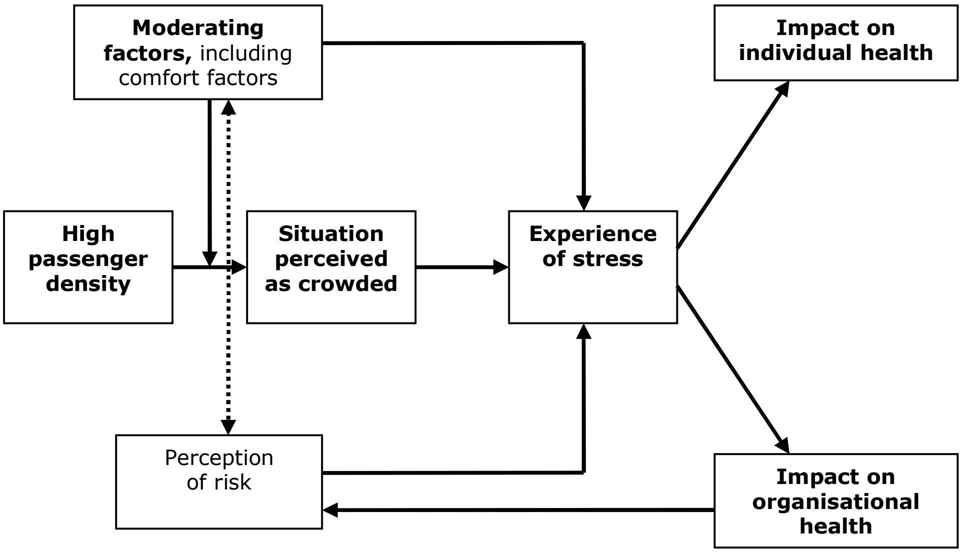

Figure 3.5. Model of crowding, stress, health, and safety. Adapted from "Rail passenger crowding, stress, health and safety in Britain" by Cox, T., Houdmont, J., & Griffiths, A., 2006, *Transportation Research Part A, 40*, p. 250.

To reiterate, the crowding, stress, health, and safety model assumes that high passenger density may lead to perceived crowding, although the relationship is imperfect. Perceived crowding may then drive the experience of stress, which, in turn, may transfer to both individual and work domains. This model makes clear the potential spillover effects of rail passenger crowding while simultaneously offering entry points for a variety of practical interventions that might enhance current crowding mitigation measures.

In addition to those points discussed in Section 2.8.3 of Chapter 2, another major area of concern highlighted in Cox et al.'s model is the importance of intervention strategies that are aimed at modifying commuters' expectations and attitudes towards the moderating factors in the density-crowding-stress relationship. More specifically, the model outlines a three-pronged intervention approach to a crowding reduction initiative that may potentially reduce subsequent stress-related effects.

The three approaches highlighted are psychological, social, and organisational interventions. Psychological interventions focus on the role of moderating factors between high density and the perception of crowdedness such as personal perceived control or coping mechanisms. The model asserts that passenger control over commuting elements such as space or choice of seat and any measures that enhance perceptions of safety and security can help mitigate perceived crowdedness, facilitate passenger comfort, and subsequently influence stress-coping ability. While social interventions may include better communication with passengers, more public education regarding appropriate travel behaviour, and improved coach and train design to ensure comfort of the ride, organisational interventions may involve a change in the structure and delivery of rail services such as the re-branding of particular rail lines purely as reliable and punctual transport services.

So far, the development of this model has been constrained by a lack of empirical data to validate its use as a tool for both understanding passenger crowding and investigating its possible spillover effects. Without the empirical testing necessary to validate the model, it is not entirely clear how and to what extent the experience of density-crowding-stress can manifest itself on individual and organisational outcomes. A validation of the conceptual model postulated by Cox et al. would therefore allow a more detailed understanding of the extent of the relationship between crowding, density, the experience of stress, and the subsequent spillover effects.

3.4 Proposed theoretical framework and operational model of the nature and effects of rail passenger crowding

The benefits and limitations of the various theoretical frameworks discussed in the previous sections highlight the breadth of the classical and integrative approaches in understanding the individual's assessment, interpretation, and reactions to density and crowding. The first option available to the thesis was to employ one of these approaches. However, by adhering to only one approach and excluding the others, the thesis risks reproducing the gaps within, and limitations of, the existing research. The second option was to integrate these approaches. However, this raised the crucial question of how to combine all elements in the various approaches within a coherent analytical framework. The third available option was to seek a new conceptual-theoretical framework that possesses such a capacity.

The theoretical review reveals that the integrative model proposed by Cox et al. (2006) provides a useful conceptual foundation for investigating the issues of interest in this thesis. Following this justification, the resultant framework developed for conceptualising this thesis as a whole relies largely upon the Cox et al.'s model, with a specific aim to provide the necessary empirical data to test and develop the model. Using this framework as a basis, an operational model was created and tested (Figure 3.6). This new model uses the summary of the theoretical discussion in structuring the research questions and describing the associations between variables. It also lists the corresponding research hypotheses; all of which are further elaborated in Sections 3.5.1 through 3.5.5. Meanwhile, the components of the operational model are discussed in Section 3.6.

The key points in the transition from Cox et al.'s (2006) model to the operational model are as follows:

1. conceptualisation and operationalisation of rail passenger crowding as a multidimensional construct;

2. incorporation of six modifying variables as control factors;

3. inclusion of a measurement of sub-optimum health status (in terms of feelings of exhaustion) alongside the experience of stress to provide a more comprehensive perspective on the direct effects of rail passenger crowding; and

4. operationalisation of spillover effects in terms of individual and work outcomes.

All these refinements are necessary in order to operationalise the Cox et al.'s original model as well as to establish a comprehensive framework that is essential to understanding the nature and effects of rail passenger crowding.

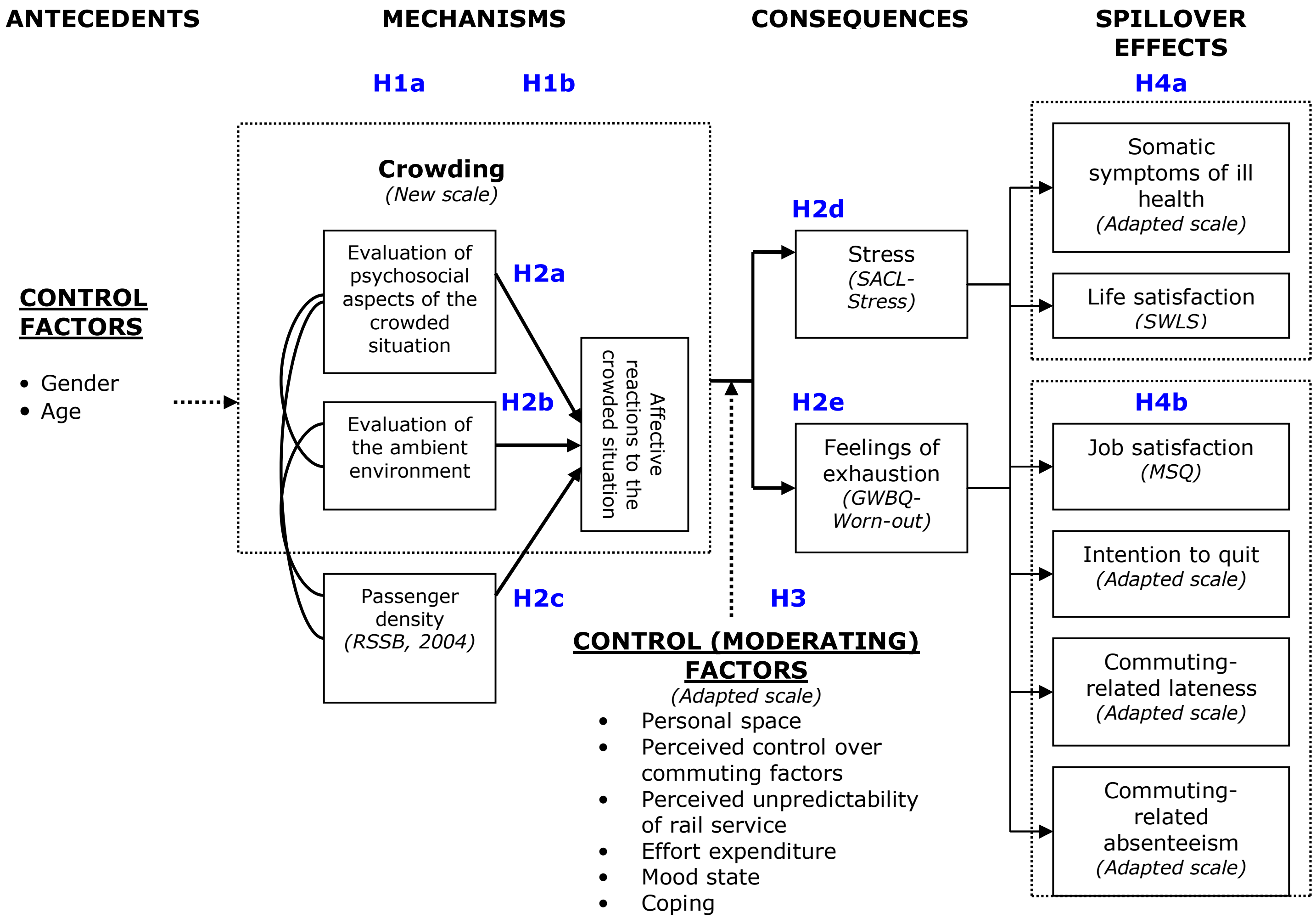

Figure 3.6. Operational model and hypotheses for understanding the nature and effects of rail passenger crowding.

Notes: Measurements are indicated in italics

H5: Comparison of possible interventions as suggested by respondents with that of Cox et al.'s (2006)

3.5 Research questions and hypotheses

The thesis aims to examine the relationships among the different psychological components of crowding (together with passenger density) and their effects on commuters' experience of stress and feelings of exhaustion. The current work also considers possible spillover effects in terms of individual and work outcomes. The exploratory and descriptive nature of this research started with a set of general questions, which were modified during the field survey study. Accordingly, five research questions and eleven hypotheses were developed and investigated.

3.5.1 Research Question One (RQ1)

The first objective of this research is to explore the possible psychological components that construct the experience of crowding. Answers to *Hypothesis 1a* and *Hypothesis 1b* are sought to meet this first objective.

H1a: It is hypothesised that the experience of crowding is constructed of three different psychological components or latent factors: (1) affective reactions to the crowded situation or affective experience of crowding, (2) evaluation of the psychosocial aspects of the crowded situation, and (3) evaluation of the ambient environment of the crowded situation.

H1b: The measurement model assumes that the three latent factors are intercorrelated, that each item loads on one and only one factor, and that the measurement errors are not correlated with one another; that is, there are no common response tendencies influencing the measures in a similar way.

3.5.2 Research Question Two (RQ2)

The second objective of the research is to examine how and in what direction does the relationships among the different components of crowding experience and passenger density affect the experience of stress and feelings of exhaustion. It is assumed that commuters' affective reactions to crowded situation are determined, at least in part, by their evaluation of the psychosocial aspects of the crowded situation and of its ambient environment, and also by rated passenger density. Commuters' affective experience of crowding, in turn, will determine, at least in part, their report of stress and feelings of exhaustion. In accordance with these assumptions, the following hypotheses are proposed:

H2a: Commuters' evaluation of the psychosocial aspects of the crowded situation will be positively related to their affective reactions to the crowded situation, such that the more the individual evaluates the situation as crowded, the more negative affective experience of crowding is produced.

H2b: Commuters' evaluation of the ambient environment of the crowded situation will be positively related to their affective reactions to the crowded situation, such that a higher evaluation of the ambient environment of the crowded situation will lead to a greater negative experience of crowding.

H2c: Rated passenger density will be positively related to commuters' affective reactions to the crowded situation, such that high ratings of passenger density will lead to an increase in the affective experience of crowding.

H2d: The affective experience of crowding will significantly predict passenger stress, such that the more unpleasantly crowded the passengers feel, the more stress they will experience.

H2e: The affective experience of crowding will significantly predict passengers' feelings of exhaustion, such that the more crowded the passenger feels, the more feelings of exhaustion they will experience.

3.5.3 Research Question Three (RQ3)

The third research question is to examine how well does commuters' experiences of crowding together with rated passenger density predict stress and feelings of exhaustion. This question addresses the following hypothesis.

H3: The different psychological components of crowding and rated passenger density will be positively related to the experience of stress and feelings of exhaustion, after controlling for demographic variables (gender, age) and individual psychological differences in the commuting experience (personal space, perceived control, commute unpredictability, mood state, effort expenditure, and coping).

3.5.4 Research Question Four (RQ4)

Following the propositions advanced in Cox et al.'s (2006) model, it is assumed that there will be spillover effects of crowding stress and exhaustion on both work and non-work outcomes. These effects will thus influence individual well-being and organisational behaviour. The following hypotheses (*Hypothesis 4a* and *Hypothesis 4b)* were developed to be more specific about the proposed nature of the spillover effects.

As highlighted in Chapter 2, the available evidence suggests that crowded commuting can potentially produce adverse physiological, psychological, and behavioural effects on individuals; for instance, raised blood pressure (Singer et al., 1978), greater stress and frustration (London Assembly Transport Committee, 2009b; Cox et al., 2006), as well as decreased satisfaction with life (Wener et al., 2006; Cassidy, 1992). Accordingly, the individual aspect of the fourth hypothesis states that any spillover effects would be made manifest in commuters' reports of somatic symptoms of ill health and decreased life satisfaction.

H4a: High experience of stress and feelings of exhaustion attributed by the joint contributions of crowding experience and rated passenger density will be related to a greater number of reports of somatic symptoms of ill health and decreased life satisfaction.

The available evidence also suggests that spillover may be associated with decreased job satisfaction (Cox et al., 2006; Koslowsky, Kluger, & Reich, 1995), increased absenteeism (Novaco et al., 1990), more late arrivals at work, and higher employee turnover (Koslowsky et al., 1995). Therefore, the work and organisational aspect of the fourth hypothesis states that any spillover effects would be made manifest in decreased job satisfaction, increased intention to quit their jobs, a greater tendency to be late for work, and increased absenteeism.

H4b: High experience of stress and feelings of exhaustion attributed by the joint contributions of crowding experience and rated passenger density will be related to decreased job satisfaction, increased intention to quit, and higher rates of lateness and absenteeism at work.

3.5.5 Research Question Five (RQ5)

The final objective of this research programme is to engage with key stakeholders in order to identify what interventions are required to resolve issues associated with rail passenger crowding. Along this line, this thesis aims to determine whether the proposed crowding mitigation measures suggested by the stakeholders would correspond to interventions proposed by the Cox et al.'s (2006) model. Hence, examining this aim involved comparing interventions recommended in the model with measures identified by the respondents in the studies reported in this thesis. Accordingly, the following hypothesis is considered:

H5: It is hypothesised that while engineering interventions would be seen as part of the solution to crowding issues in the rail industry, psychologically oriented interventions would also be viewed as effective and beneficial in guiding the development of a broader crowding management policy and planning.

3.6 Model components

The components of the operational model (Figure 3.6) are conceptually defined and discussed in the following sub-sections. However, details of the measures for each theoretical construct are discussed in Chapters 6 and 7.

3.6.1 Experience of crowding

The distinction between passenger density and perceived crowdedness or crowding has been established by a number of researchers (for example, Cox et al., 2006, Turner et al., 2004). Studies by Kalb and Keating (1981) and Mohd Mahudin (2003) suggest that further distinctions can be made between crowding experience, the essentially psychosocial characteristics of the crowded situation, and those of its ambient environment. All three components of crowding, along with passenger density, may have roles to play in determining both its direct and spillover effects. Following this approach, this thesis conceptualises the experience of crowding in terms of commuters' evaluations of the psychosocial aspects of the crowded situation and of its ambient environment as well as their affective reactions to the crowded situation. The basis for conceptualising crowding experience in this manner is further discussed in Chapter 6.

3.6.2 Passenger density

Passenger density, which is customarily defined as the number of boarding passengers per unit space during a trip (Fritz, 1983), can be estimated using seating and standing capacity, as discussed in Chapter 2. In this thesis, passenger density is defined as the extent to which commuters rate the total number of passengers travelling based on four pictorial cue representations of commuters of increasing crowd density (RSSB, 2004).

3.6.3 Antecedent factors to the experience of crowding

Antecedent factors influence commuters' experience of crowding. Included in this research are personal factors, namely gender and age. Several studies report some gender differences in crowding experience, most notably reflected in greater male aggression and withdrawal (Baum & Paulus, 1987; Sundstrom, 1978) as well as greater discomfort among females than in males after long-term exposure to high room densities (Sundstrom, 1978).

3.6.4 Direct effects of the experience of crowding

The specific aspects of the outcomes that are of interest depend on the context of the research. As shown in Chapter 2, only a few studies deal with the consequences of crowding on trains, with even fewer investigating the processes and mechanisms underlying this relationship. In these studies, the measures of interest are mainly the moods and emotions experienced during the commute or during work–home life such as physiological stress, psychological annoyance, and behavioural outcomes.

Understanding that the direct effects of crowding experience can be construed differently depending on the study, the current work focuses on two stress-related outcomes. The first of these, psychological stress, is typically defined as the experience of negative events or the perceptions of distress and negative affects that are associated with the inability to cope with them (Stone, Mezzacappa, Donatone, & Gonder, 1999). The basic components of psychological stress may include pressure, tension, anxiety, conflict, threat, frustration, and loss (Sharma, Malhotra, & Malhotra, 2010). The second stress-related outcome is the feelings of exhaustion, which can be characterised by being worn out, fatigued, exhausted, and sluggish (Cox, Thirlaway, Gotts, & Cox, 1983).

3.6.5 Control factors between the experience of crowding, rated passenger density, and direct outcomes (experience of stress and feelings of exhaustion)

Six variables, which can potentially influence stress reactivity to a crowded commuting experience, were included in order to control extraneous sources of variance. First, studies have shown that lack of personal space in public transportation creates a highly stressful situation for passengers (Evans & Wener, 2007). Personal space is defined as an area with an invisible boundary surrounding the person's body into which intruders may not come (Sommer, 1979). When this boundary is intruded upon, individuals may experience stress and feelings of discomfort (Hall, 1966).

Second, a stressful commuting experience can be affected by the individual's perceived control over their commute. The effects of crowded commuting will be more salient when passengers perceive that their personal control over their journey is reduced by a number of factors, for example delays or cancellations. Perceived control reflects the nature and degree of control that individuals believe they are able to exercise over events in their lives (Ferguson & Cox, 1996). Several factors within a given environment may enhance an individual's sense of control over his or her interactions with others. This sense of control may help reduce the crowding experience and ease the associated stress.

Third, studies have shown that stressful commuting does not only correlate with the duration or distance travelled, but also with the unpredictable nature of the commute (Evans, Wener, & Phillips, 2002; Koslowsky et al., 1995). According to Kluger (1998), commute predictability is defined as "the ability of the commuter to mentally predict impedance or the length of the commute" (p. 151). Traffic congestion, for instance, is consistently reported as increasing the unpredictability of the commute, resulting in an increase of stress (McLennan & Bennetts, 2003; Novaco et al., 1990).

The fourth factor that could potentially modify the relationship between rail passenger crowding and its outcomes is effort expenditure. In this study, effort expenditure refers to the degree of willingness to invest time, effort, and energy into the commuting process. Several studies have shown that commutes which involve changing modes of transport are likely to lead to increased effort expenditure and intensify the adverse effects of crowded commuting (Wener & Evans, 2004; Evans, 2001).

It is also likely that stressful commuting can be influenced by people's general mood disposition and their present mood state. Previous research shows that the dispositional nature and current mood state can affect individual reports of environmental conditions and symptoms in such a way that those who tend to evaluate events in negative terms are likely to report distress, thus producing exaggerated claims about the outcomes (Wener & Evans, 2004).

The final factor that may contribute to stressful commuting is coping. Coping involves "a complex process of thoughts and actions" and can be defined as "cognitive and behavioural efforts by individuals to master, reduce, or tolerate the demands imposed by stressful conditions" (Dewe, 2000, p. 27). In this context, individuals' efforts to cope with the various demands related to commuting can alter their personal perception of the stress experienced. A wide range of coping strategies, including emotion-focused coping and task-oriented techniques, has been reported to have an impact on stress reactivity while commuting (Wener & Evans, 2004; Matthews, 2002). This finding thus lends support to the inclusion of this variable as one of the control factors in the present work.

3.6.6 Spillover effects of the experience of crowding

Studies have demonstrated that the boundaries between the commuting, home, and work domains are permeable in such a way that the commuting experience can have a detrimental effect on both individual health and organisational behaviour and well-being (Cox et al., 2006; Koslowsky et al., 1995; Novaco, Kliewer, & Broquet, 1991; Novaco et al., 1990). In this thesis, spillover describes a two-way interaction between the commuting experience and more general work and life experiences. Studies highlighted in Section 2.8.2 of Chapter 2 (for example, Cox et al., 2006; Passenger Focus, 2006; UK House of Commons Transport Committee, 2003; Cassidy, 1992; Costa et al., 1988) and other studies in the general commuting literature have uncovered the spillover effects of commuting on a variety of individual work and organisational outcomes. These effects include work-related stress, lost workdays, late arrival at work, workplace aggression, and job location change (Hennessy, 2008; Novaco, 2001; Koslowsky et al., 1995). Additionally, stressful commuting conditions can spill over into home life, creating a more negative mood at home (Wener & Evans, 2004; Novaco et al., 1991; Novaco et al., 1990).

3.7 Chapter summary and conclusions

A large portion of this chapter has been given over to a discussion of the theoretical approaches that can guide research efforts in this area. While the inadequacies of the existing approaches are manifest, several options for improving the overall theoretical framework are available. One such option is to develop and test a refined model for evaluating the effects of rail passenger crowding and illustrating the relative impact in both the individual and organisational domains. This chapter has formulated a thesis that the integrative model proposed by Cox et al. (2006) could be broadly applied to investigate the relationships among the different psychological components of crowding and their direct and spillover effects. On the basis of this thesis, a series of testable research questions and hypotheses have been generated, which seek to examine the key variables associated with rail passenger crowding and its role on passengers' stress, feelings of exhaustion, and the associated spillover effects.

Having discussed the available theoretical frameworks on crowding and the operational model resulting from them that can be used for the present work, the following chapter outlines the research methodology applied throughout this thesis. The range of available methodologies that can be used to provide data to investigate the identified research questions are reviewed and the methodological approach chosen is explained and justified.

CHAPTER 4 - RESEARCH STRATEGY AND METHODOLOGY

4.1 Chapter overview

This chapter focuses on the methodological strategy and research design used to investigate the research questions and hypotheses identified in Chapter 3. The first part of this chapter evaluates the differences between possible research designs (Sections 4.2.1 to Section 4.2.4), and on the basis of this, presents the argument for the methodology chosen (Section 4.3). Essentially, the present data were collected using a combined research strategy of an interview-based survey of key stakeholders and a questionnaire-based quantitative survey of passengers. The first survey was aimed at uncovering the perceptions of key stakeholders in the rail industry regarding passenger crowding and other critical issues within the context of rail services in Malaysia. Using a questionnaire consisting of open-ended questions, all data collected through this survey were analysed for themes related to issues such as ridership statistics, reliability and service quality, passenger load and train capacity, challenges and constraints faced by the rail industry, and future plans to address the specified challenges. Meanwhile, the quantitative passenger survey was aimed at examining the relationships among the different psychological components of crowding and their direct and spillover effects on commuters. The survey data were analysed using multivariate analyses and structural equation modelling (SEM). The second part of the chapter ends with a discussion of important practical issues in research design, including sampling and measurement as well as ethical issues and how they were dealt with.

4.2 A choice of research strategies

Having discussed the key issues to be addressed (Chapter 1), reviewed the previous attempts to investigate these issues (Chapter 2), and developed the research questions (Chapter 3), what follows is a discussion on the choice of strategies that are available for researching issues relating to rail passenger crowding and its outcomes. These strategies, which include correlational studies, experiments, and field studies, are critiqued below alongside a discussion of the range of methods used by researchers in studying crowding in the rail literature. The aims, objectives, and any practical constraints of context necessarily influence the designs and approaches adopted in any study (Robson, 2011). Those employed within this thesis are justified in the following discussions, with an indication of how these add to the existing knowledge and serve to inform each other.

4.2.1 Correlational studies

Human crowding research has its roots deep in correlational studies from sociological tradition (Altman, 1978). Early studies within this tradition primarily involved examining statistical covariations between aggregate measures of population density (for example, people per unit of area or people per census tract) and social pathology indicators such as crime and juvenile delinquency (Booth & Welch, 1973; Schmid, 1970), physical and psychological health (Michelson, 1970; Faris & Dunham, 1965), or mortality rates (Levy & Herzog, 1974; Galle, Gove, & McPherson, 1972). Many such studies found moderate relationships between population concentration and social pathology, and hence suggested that crowding had harmful effects on human well-being.

Although correlational research made a reasonable case demonstrating the effects of population density on a wide range of social pathological outcomes, it has also been criticised in a number of ways. The main criticism of the early correlational studies is that they do not confirm causation. In particular, population density does not necessarily cause social pathology, as there are other factors such as social, economic, health, and ethnicity that may have accounted for the results. Studies such as those by Freedman (1975) and Galle et al. (1972), for instance, found that the substantial positive correlations between density and various pathologies disappear when income and ethnicity are partialled out. Similarly, Winsborough (1965) reports that density has little or no independent effect on pathology after controlling for factors such as economic, educational, and migration levels.

In relation to the issue of causal inference, there exist the problems of multicollinearity and ecological fallacy in correlational studies (Fischer et al., 1975). The former refers to high intercorrelations among various explanatory variables, which render it difficult to make any statistically meaningful conclusions about the relationship between population density and pathologies, while the latter includes inferring crowding effects on specific groups based solely on aggregated data. Baum and Paulus (1987) argue that aggregate measures of density may not accurately reflect the actual crowding experience and may mask relationships that exist at the individual level.

Problems of interpretation in correlational studies also arise from the differing population density measures and various pathology indicators used. In his review, Altman (1978; 1975) argues that little attention was given to differentiating between the various levels of density as different indices were employed. While most correlational studies used large geographical units such as people per census tract or people per nation, only occasionally were measures based on small social units such as people per dwelling unit employed (Altman, 1975). This resulted in difficulty to systematically compare the density measures and interpret the emerging results (Baum & Paulus, 1987).

Another criticism of correlational studies in crowding research is their strong emphasis on social-system outcomes rather than on social processes. Researchers such as Altman (1978; 1975) believe that crime rates, mental illness, and disease are the results of a long social experience and therefore may not be able to adequately explain the ongoing social interaction as individuals cope with the high-density conditions. He further argues that the early correlational studies tend to focus on societal solutions to alleviate crowding in the form of changes in dwelling units and environmental planning instead of offering individual, psychological solutions (Altman, 1978).

In light of the aforementioned criticisms, researchers have attempted to improve the correlational-sociological research design by employing various techniques, including giving more attention to the interpersonal level of density, focusing on the interpersonal social processes that occur in high-density conditions, and statistically controlling for confounding variables that might account for density-pathology relationships (Altman, 1975). More recent correlational studies are better designed and controlled as well as having a better conceptualisation of density. For example, in a series of studies examining the relationship between children's mental health and residential crowding, Evans, Lercher, and Kofler (2002) found that children from higher density homes are more likely to report psychological health problems and to experience increases in behavioural disturbance as well as less likely to persist in an achievement, problem-solving context in comparison to children who lives in less crowded homes (Evans, Saegert, & Harris, 2001).

Despite these improvements, researchers believe that the correlational approach still suffers from some drawbacks, such as: (1) different variations of density indices are still being used and this hinders a meaningful comparison among studies, (2) an inability to specify the causes of urban pathologies, and (3) the self-selection of individuals into the areas or housing being studied may potentially confound the interpretation of the effects of high density on pathology (Bell et al., 2001; Baum & Paulus, 1987; Epstein & Baum, 1978).

4.2.2 Experimental studies

An alternative approach to the correlational-sociological methodology is to take a positivist stance to research by applying experimental techniques that emphasise control, manipulation, and causation to generate quantitative data. This approach, which is deeply entrenched within the social psychological tradition (Altman, 1978), aims to minimise the effects of confounding variables in such a way that key independent variables can be manipulated and their effects on dependent variables can be identified and measured. The antecedent variables in laboratory and field experiments typically involve manipulation of various forms of density levels, while multiple measures based on physiological reactions, responses to questionnaires, performance of tasks, nonverbal behaviours, and other responses usually serve as the outcome variables, controlling for all other setting and personal characteristics (Baum & Paulus, 1987; Sundstrom, 1978).

Experimental studies, however, show mixed results, with some yielding negative effects of density on task performance (for example, Dooley, 1978; Paulus, Annis, Seta, Schkade, & Matthews, 1976) and psychological states (for example, Baum & Paulus, 1987), while others showing weak or no effects (for example, Altman, 1978; Freedman, Klevansky, & Ehrlich, 1971). It is likely that this happens because of the challenges faced to adequately identify and control for all the confounding factors in the experimental setting. While experimental research can be helpful in understanding the causal effects of crowding, findings from such studies need to be interpreted cautiously because of the possibility that their findings are not generalisable to the real world and that the results may be restricted to the specific experimental setting. Furthermore, because the term “density” was used interchangeably with “crowding”, the different levels of density measures manipulated do not always accurately reflect the degree of subjective crowding experienced (Baum & Paulus, 1987).

4.2.3 Field studies

Following the criticisms of the correlational and experimental approaches, researchers have increasingly collected data using field research techniques because such techniques can offer greater generalisability and realism of context than laboratory experiments (Bell et al., 2001). One recent example was a field experiment conducted by Bruins and Barber (2000), who found that participants who were asked to locate various products in a store under crowded conditions showed a greater decline in mental performance and a lower positive affect in comparison to their counterparts who performed a similar task under uncrowded conditions. Similarly, several correlational field studies examining crowding in open-office workspaces report that crowding reduces satisfaction with the workspace, which, in turn, strongly affects employees' job performance, experienced privacy, and their withdrawal behaviours toward the organisation (May et al., 2005; Brennan, Chugh, & Kline, 2002; Oldham & Fried, 1987).

Bell et al. (2001) argue that while field experiments do allow for conclusions concerning a cause and effect relationship, similar inferences could not be made in cross-sectional field studies. Alternatively, quasi-experiments, which are field experiments in which one variable is controlled while all others are left to vary as they naturally occur (Shadish, Cook, & Campbell, 2002), can adequately address these concerns. This method allows causal inferences to be made and maximises both the experimental realism (the degree to which the experiment can involve the participants and get them to behave in a way that it is meaningful to the aim of the study) and mundane realism (the extent to which the experimental situation is real-world like) of the field settings (Gefen & Ridings, 2002). One example of a quasi-experiment conducted in this area is a study by Oldham (1988), who found that relative to employees in a control office, employees who moved from an open-plan office to either a low-density open-plan office or to a partitioned office experienced significant improvements in task privacy, communication privacy, crowding, and office satisfaction. Similarly, in a series of studies investigating how temperature and crowding affect attitudes and behaviour, Ruback and Pandey (1992) found stronger effects for crowding than for heat on physical symptoms such as headache and sweaty hands and verbal aggression among passengers in three-wheeled auto rickshaws.

The primary setback to applying the field study design is the lack of randomisation that may result in uncontrollable subject variance (Epstein & Baum, 1978). Furthermore, in many research situations, it is relatively difficult to have complete control of extraneous variables or to find an equivalent control group in the natural settings. Researchers, however, argue that this design can be very useful in studying crowding if it is aptly designed to overcome these limitations (Bell et al., 2001; Baum & Paulus, 1987; Epstein & Baum, 1978).

While correlational studies provide information about the possible consequences of urban density, experimental studies have uncovered important evidence reflecting various antecedents and the effects of crowding. Quasi-experimental studies, however, have eliminated some of the methodological limitations inherent in the existing correlational and experimental research. All these methods are deemed useful for generating theory and are equally important in order to develop a full understanding of crowding.

Considering these circumstances, four methodological advances were proposed to overcome the limitations related to the previous methodological traditions within crowding research (Altman, 1978). First, greater attention was paid to an integration of approaches and a diversity of research techniques in a broadly based eclectic design. Such a design typically combines elements from traditional laboratory settings and observational analyses in various combinations, with two possible dependent variable strategies: 1) use of naturally occurring responses appropriate to the situation (for example, illness rates), and 2) use of restructured and improved responses (for example, questionnaires, simulation tasks, and cognitive and performance tasks). Second, measurement of multiple dependent variables has gained more prominence in crowding research. This strategy involves combining verbal and non-verbal behaviours, feeling states, and environmentally-related behaviours to provide information on human behaviour patterns. Another important development is a greater emphasis on analysing the social processes (for example, the context and form of interaction or problem-solving processes) linking human crowding to psychological states (for example, stress, anxiety) and interpersonal states (for example, feelings of attraction or hostility toward others). Finally, methodological strategies that recognise the temporal aspects of crowding are introduced, with an examination of the immediate and delayed effects of crowding on direct and indirect outcomes.

4.2.4 Methodologies adopted in studying crowding in the rail literature

Existing studies in the field of rail crowding (the research domain to which this thesis belongs) have applied both correlational and experimental approaches as well as exploratory and field designs in their investigations. A majority of these studies, however, are descriptive and cross-sectional in nature. Descriptive research typically involves collecting data that describe variables of interest, uses description as a tool to organise data into patterns that emerge during analysis, and explores the measurement of phenomena without testing hypotheses (Coolican, 2004; Knupfer & McLellan, 1996). Some studies in this research area synthesise data derived from the existing literature (for example, Cox et al., 2006; Gershon et al., 2005; Cox et al., 2002), while others take the descriptive design one step further by employing more qualitative methods for analysing oral and written evidence (for example, London Assembly Transport Committee, 2009a; Weyman et al., 2005; House of Commons Transport Committee, 2003) as well as reviewing accident or injury data (for example, Bottomley, 1999; Lerer & Matzopolous, 1996) to inform their conclusions and recommendations. While descriptive research can provide some information about the nature, prevalence, and consequences of crowding on trains, it cannot isolate any cause and effect relationships, which, in turn, may imply low internal validity. Furthermore, inferences drawn from either a literature or evidence review need to be considered with some caution, as they are prone to selection and publication bias, including the propensity to use evidence that is readily available and the tendency to select sources with favourable results that are consistent with the review's objectives (Song, Eastwood, Gilbody, Duley, & Sutton, 2000).

On this point, the systematic review of the literature in Chapter 2 has identified 12 studies that used a cross-sectional, correlational approach to examine the link between passenger crowding and stress and other associated outcomes (for example, Cantwell et al., 2009; Evans & Wener, 2007; Buckley & O'Regan, 2004; to name a few), making it the second most preferred method in rail crowding studies. This preference derives perhaps from the design's flexibility in examining the association between variables through correlation and regressions while simultaneously showing the generality of theoretical implications without establishing causation (Gefen & Ridings, 2002). It is also arguable that a cross-sectional design is chosen because of its advantages of being easier, quicker, and less expensive to conduct than longitudinal or experimental studies. Despite these advantages, cross-sectional studies in this research area suffer from similar weaknesses as the correlational approach discussed earlier, including the unsuitability for detecting and testing causal relationships, the inability to rule out alternative explanations or to link exposure to outcome in individuals, and the lack of control for confounding factors (Grimes & Schulz, 2002).

In only two studies identified in the systematic review of the literature were data collected from laboratory experiments. Pittard and Jackson (1992) conducted a series of experiments to examine passengers' evacuation performance from an overcrowded railway coach, in which they were able to identify psychological factors such as individuals' willingness to compete with others and their levels of self-consciousness that played greater roles in predicting evacuation performance at higher crowding levels. Experiments performed by Nicol et al. (1973), however, established the detrimental effects of crowded trains on the participants' discomfort levels. Although both studies are able to show causation that preceded the associated effects, the external validity of laboratory experiments cannot be established as soundly as in cross-sectional surveys because of the limited sample size, the artificiality of laboratory conditions, and because of uncertainty whether the participants really represent the population of interest in real-world settings.

To address some methodological criticisms of the experimental designs, researchers in this avenue of research have moved their investigations of treatment groups and outcome measures from controlled laboratory research to actual field settings. Pioneered by the seminal works of Lundberg (1976), Singer et al. (1978), and Evans, Wener, and Phillips (2002), quasi-experiments were conducted to investigate the physiological and psychological stress arising from commuting in crowded trains. While this design is able to maintain experimental and mundane realism, the plausible explanation that is made about the relationship between crowding and its outcomes and the limited ability to randomly assign participants to treatment groups may limit the conclusions that can be drawn from this method alone.

There is also a growing trend towards integrating quantitative and qualitative data collection and analysis techniques to generate a more holistic view of the relationship between rail crowding and its outcomes. By combining data from survey questionnaires, injury and incident analyses, literature reviews, stakeholder consultations, and passenger behaviour studies, research works such as those by Davis Associates (2008) and Turner et al. (2004) are able to provide a wealth of data on health and safety issues related to train overcrowding. In another series of investigations aimed at the identification of psychological and physiological stress experienced by train commuters and their spillover effects to home and work, Wener et al. (2005; 2004) used multi-method approaches in collecting cortisol responses, self-rating questionnaires on stress as well as measures of performance tasks from their participants.

While some researchers have used correlational and experimental methods to explore similar issues, researchers who have used the multi-method approach argue that the approach is more robust and accurate than the traditional research designs, as it can adequately generate stronger evidence for a conclusion through convergence and corroboration of the qualitative and quantitative findings (Onwuegbuzie & Leech, 2006; Johnson & Onwuegbuzie, 2004). With that in mind, a broader range of research questions can be explored because they are not confined to a single method or approach. Another merit of the multi-method approach lies in its ability to not only overcome the weaknesses in one method but also add insights and understanding that might be missed when only a single method is used. This, in turn, can increase the generalisability of the results and provide more substantial evidence on which to base the research conclusions.

There are, however, certain limitations to the use of a multi-method or eclectic approach. Traditionally, the arguments against such an approach centre on the timing, weighting, and mixing decisions that are made in each of the different designs. For example, Johnson and Onwuegbuzie (2004) assert that researchers have to learn multiple methods and understand how to mix the findings appropriately. This process becomes even more challenging, as some of the details of eclectic research are still debatable among research methodologists (for example, problems of how to qualitatively analyse quantitative data and how to interpret conflicting results). As a result of these challenges, conducting an eclectic study is likely to be more expensive and time consuming than using a single approach.

4.3 Rationale for the research methodology and data analysis used in this thesis

4.3.1 Research design and context

The previous sections have discussed and critically evaluated the research methodologies that can possibly uncover the relationships between crowding and its associated outcomes. The answer as to which approach should be preferred to address the research questions lies in the nature of the research questions posed. It is quite apparent that the correlational approach under the sociological tradition is valuable if the research questions are to investigate urban or population density and social pathology. However, if one wishes to examine the relationships among the different psychological components of crowding and their direct and spillover effects on commuters, then a sociologically-based correlational methodology would not be appropriate because no or limited data on subjective crowding or on social pathological outcomes in transportation settings are available. An experimental approach, whereas, would permit direct inferences about the possible effects of rail passenger crowding. However, there are significant complexities in human behaviours that are related to various environmental factors in specific transportation setting, making it difficult to exactly simulate the conditions in an experiment. Field studies that consider the differing psychological components of crowding and use multilevel analysis of dependent variables would, however, allow a valid and comprehensive investigation of the direct and spillover effects of rail passenger crowding.

The research questions generated in this thesis ask for an analysis of the effects of the different psychological components of crowding on passengers, considering the outcomes in both the individual and organisational domains. What is needed, therefore, is an alternative methodology and analysis that encompasses elements of correlational and experimental traditions. This thesis thus adopts an eclectic research design that involves modelling the pathways that may link the different components of the crowding experience with passenger density and its direct and spillover effects. More specifically, a combined descriptive and correlation-type design conducted in the field setting is considered to be the most adequate way to gather data on the experiences of rail passenger crowding in Malaysia.

The descriptive component of this research can be classified as a survey study, as the opinions of the key stakeholders on the research topic are sought and analysed. The main reason for selecting this design is because of its ability to capture a broad base of information from the key stakeholders, making it possible to obtain the necessary data concerning the regulation, operation, and management of rail passenger services in Malaysia. In addition, this research design allows a deeper exploration of the current perceptions of rail passenger crowding among the key stakeholders and probes their views on current and future plans to address challenges confronting the rail industry.

The cross-sectional, correlational component of this thesis involves an extensive passenger survey which was conducted to explore commuters' experience of crowding and how it affects their commuting experience, work, and life. This survey was designed in such a way that some quasi-experimental features were used; for instance, controlling for variables such as commuting frequency and duration and collecting all data in its field setting. By doing so, precise numerical data can be obtained and quantitative predictions can be made. Within this design, too, both passenger density and the experience of crowding were investigated and multilevel analyses of dependent variables were measured using naturally occurring responses appropriate to the situation (for example, stress, feelings of exhaustion, and physical or somatic symptoms) as well as restructured and improved responses from questionnaires on organisational and individual outcomes (for example, job and life satisfaction, intention to quit, and commuting-related absenteeism and lateness).

One justifiable use for adopting an eclectic design in this thesis is for a participant enrichment purpose; that is, to get a wider, multi-stakeholder view on the research questions (Collins, Onwuegbuzie, & Sutton, 2006). Although there is some evidence from previous studies that explore similar issues on crowding and its outcomes (as shown in Chapter 2), the stakeholder's participation is limited either only to train operating companies or passengers in mono-method investigations rather than broader public participation. However, taking an eclectic approach will allow the data on the process and context of the effects of rail passenger crowding to be collected and analysed without excluding any stakeholders.

Furthermore, the combination of descriptive, correlational, and field study is effective for achieving the thesis aims because the researcher can maximise the interpretations of the research findings, what Onwuegbuzie and Leech (2006) coin as "significant enhancement". The quantitative analyses from the passenger survey can be used to supplement and to some extent clarify the data obtained from the descriptive study. Moreover, the choice of eclectic design allowed the researcher to gauge how respondents' perceptions and experiences of crowding are influenced by the wider psychological contexts in a timely and cost-effective manner.

4.3.2 Research setting and location

All studies reported in this thesis were conducted in Kuala Lumpur, Malaysia, in which both key stakeholders and commuters were asked for perceptions and experiences of rail passenger crowding. There were three major reasons for selecting this area as a target location for this research work. First, while there is a wealth of research on crowding conducted in various research settings and regions, relatively little psychological research is available that reports crowding-stress relationship in Malaysia. Although there exists some documented studies of crowding in areas such as population and urbanisation (for example, Kennedy, Hossain, & Chan, 2006; Low, Zulkifli, & Yusof, 2002) as well as in prison or hospital settings (for example, Hill, 2001; Chin, Kadir, & Jeyarajah, 1993), empirical studies of its impact within the transportation setting in Malaysia are almost nonexistent. Furthermore, the preceding studies mostly focused on density, which is a concept distinct from crowding. Nonetheless, the issues these studies raise imply that high population density combined with other environmental or situational factors can potentially exert negative effects on individuals' physical health and personal well-being, which may include increased risks of communicable diseases and psychological stress. Considering these findings, it is therefore possible that similar outcomes would be observed if the same types of study were conducted in a transportation setting.

Second, most studies of commuting in Malaysia generally focus on transport planning and management or on travel behaviour and commuting pattern (for example, Sharifi, Boerboom, Shamsudin, & Veeramuthu, 2006; Zakaria, 2003; Leong, Jen, & Mohd Sadullah, 2009). Only recently has a study been conducted that examines factors that cause people the most stress during their commute (Regus, 2011). According to this study, dangerous drivers topped the list of major stress factors experienced by Malaysian commuters, followed by delays and service interruptions, pollution and overheating, road rage, and a lack of information from service providers. Despite the informative nature of the research, Regus's study merely identified the factors that contribute to the strain of commuting and did not report the empirical basis for the relationship among these factors. Furthermore, public transport crowding and road congestion are not explicitly studied in this research.

Third, anecdotal journalistic accounts, governmental publications, and public transport advocacy group reports have increasingly revealed that train overcrowding negatively affects commuters' satisfaction with the service offered (for example, Abdullah et al., 2008; Performance Management and Delivery Unit (PEMANDU), 2010). Although this scenario is observed in most major cities around the world, it is especially prevalent in Malaysia where crowded commuting and congested traffic patterns are more intense than in previous years. In light of these observations, a new study investigating the nature and effects of rail passenger crowding in Malaysia appeared highly desirable.

4.3.3 Sample and sampling issues

4.3.3.1 <u>Specifying the target population</u>

The specification of the population for analysis is an important aspect of a research program, as it involves consideration of the purpose of the study, study design, and accessibility to potential participants (Coolican, 2004). For the investigation of the nature and effects of rail passenger crowding within this work, strategies were designed to produce a study sample that was representative of commuters and key stakeholders in Kuala Lumpur's rail-based public transportation. With regard to the first study, the participants included key stakeholders from a wide range of sectors such as government and non-government organisations, train operating companies or rail operators, and regulatory authorities. This selection of participants was deemed to be the most suitable sampling method for this study because it provided the scope needed to collect an appropriate amount of evidence from the key stakeholders. Furthermore, the diversity of participants ensured that insights into stakeholders' perceptions of rail passenger crowding and critical issues affecting the rail industry were adequately gained.

Meanwhile, the second study collected its data from 525 passengers. Sampling strategies for this particular study were constrained by the need to target a wide range of commuters who, at the very least, had similar crowding experiences and commuting characteristics. Otherwise the experience of stress and feelings of exhaustion could have been attributed to other situational or environmental factors. For this reason, only those who commuted to work regularly and frequently by train were included in the sample. In particular, the inclusion criteria were: use of the service at least three days each week and use of the same route for at least six months.

4.3.3.2 Sampling type

Stakeholders involved in the fist phase of the present work were purposely chosen because of their roles in policy formation and enforcement as well as in transportation coordination and operation. The use of a purposive sampling technique here was justified on the grounds that the key stakeholders selected could provide rich information about issues of central important to the purpose of the research (Patton, 1990).

Meanwhile, respondents for the passenger survey were recruited according to a stratified quota sampling method, using the type of rail line as the stratification variable. In this sampling method, the size of samples drawn from each specified stratum is proportionate to their size in the target population (Coolican, 2004). Following this criterion, the target sample sizes in the present research were chosen so as to be as close as possible to the actual daily ridership of the rail lines selected. An elaborate discussion about this procedure is given in Section 7.4.1 of Chapter 7. This sampling method was useful for this study because it ensured that elements from each stratum in the population are represented in the sample. By doing so, the representativeness of the study population was improved.

4.3.3.3 Sample size and statistical power consideration

Several variations have been reported to estimate sample size and statistical power in regression and SEM analyses, with the general guideline being that larger samples are needed as more measured variables and parameters are included in the analyses. This general guideline is especially relevant for the study in Phase Two. Field (2005) suggests that the required sample size for regression analyses depends on the anticipated size of the effect. For instance, if one expects a large effect, a sample size of 80 will be sufficient, whereas a sample size of 200 is adequate to achieve a medium effect size. Alternatively, a larger sample size (at least 600 cases) is required to detect a small effect size (Field, 2005, p. 174).

There is little consensus of opinion about the recommended sample size for the SEM technique (Sivo, Fan, Witta, & Willse, 2006; Tomarken & Waller, 2005). The assessment of power in the framework of SEM is also rather complex because more parameters are involved, thereby a traditional protocol for power analysis such as those employed for the t-test or ANOVA is not entirely feasible in SEM (Kaplan, 1995). Nevertheless, several approaches to computing power analysis for SEM models are available (for example, MacCallum, Browne, & Sugawara, 1996; Kaplan, 1995; Satorra & Saris, 1985). The approach described by MacCallum et al. (1996) for determining sample size and power for covariance structure models was considered in this thesis because it provides a suitable power estimate at the model level. This approach calculates the minimum sample size for tests of model fit on the basis of the root mean square error of approximation (RMSEA) index, where a value that is less than .05 indicates a close approximate fit; values between .05 and .08 suggest a reasonable error of approximation; and a RMSEA value greater than .10 suggests a poor fit (Kline, 2011). In addition, the power of a model is good if it is greater than .80 because there is 80% chance that an incorrect model is rejected (Kline, 2011).

Using a webpage utility by Preacher and Coffman (2006), which was developed to compute power analysis based on MacCallum et al.'s (1996) approach, the minimum sample size required to achieve a statistical power of .80 for the SEM model in this research was determined. With H_0: RMSEA = .05 and H_A: RMSEA = .01 (that is, a not-close-fit null hypothesis), α = .05, df = 42, and power = .80, the minimum sample size required is 297 (see Appendix C for the syntax). Therefore, the passenger survey study, with a total sample size of 525, more than meets this requirement.

Another guideline available is that one must have a total sample size (N) that is greater than the number of observed variables in order to conduct a parameter estimation using Maximum Likelihood (ML) methods. Under this condition, Kline (2011) advocates that N should not be less than 100 and suggests that for statistical precision, the ratio of cases to parameters should not be below 5:1. As depicted in Table 4.1, which breaks down the number of parameters in the model tested in this thesis, there are 24 parameters to be estimated. Therefore, in order to meet these requirements, a minimum N of 120 would be required. With an N of 525, the passenger survey study also meets this requirement.

Table 4.1.

Parameters in the SEM model tested in this thesis

Parameters	**No**
Distinct sample moments:	66
Parameters to be estimated:	24
Degrees of freedom (66 - 24):	42
Total variables in the model:	19
Number of measured variables:	11
Number of unobserved variables (errors):	8

4.3.4 Measures and measurement issues

In Phase One, a questionnaire was developed to gather information regarding stakeholders' perceptions of rail passenger crowding and other critical issues as well as their plans for overcoming the problems the industry is facing. Participants responded in written form to five categories of open-ended questions about ridership statistics, reliability and service quality, passenger load and train capacity, specific issues surrounding rail passenger services, and future plans to address the specified issues (see Section 5.4.3 of Chapter 5 for a detailed discussion of this questionnaire and Appendix D for the instrument).

Meanwhile, respondents in the passenger survey (Phase Two) completed a questionnaire incorporating (1) demographic questions; (2) crowding experience and passenger density measures; (3) two direct outcome measures: the stress subscale of the Stress and Arousal

Checklist (SACL: Gotts & Cox, 1988) and the worn-out subscale of the General Well-Being Questionnaire (GWBQ: Cox & Gotts, 1987); and (4) six spillover effect variables: the Satisfaction with Life Scale (SWLS: Diener, Emmons, Larsen, & Griffin, 1985), somatic symptoms of ill health, Minnesota Job Satisfaction Questionnaire (MSQ: Weiss, Dawis, England, & Lofquist, 1967), intention to quit, as well as absenteeism and lateness to work due to the commute (see Appendix E for the instrument). The questionnaire also included 31 items measuring six control variables: lack of personal space, perceived uncontrollability over one's commute, unpredictability of the commute, perceived effort expended during the commute, mood state during the commute, and individuals' efforts to cope with the various demands related to commuting. A more thorough discussion of the development of the crowding experience measures is provided in Chapter 6, while a detailed description of all measures in this survey is given in Section 7.4.4 of Chapter 7.

Both instruments used self-report questionnaires to measure perceptions and experiences of rail passenger crowding and related variables. Self-report assessments are appropriate for measuring the intended variables and answering the stated purposes of the research because they permit immediate access to respondents' perceptions, viewpoints, and opinions on the issues under question, which may be unobtainable in any other way (Razavi, 2001). Furthermore, self-reporting methods are easy to administer, cost-effective, and non-intrusive (Razavi, 2001). These were therefore practical for the current research purposes.

While self-reporting methods have been widely used in previous research in many fields, they are nevertheless not without any criticism. Key debates have centred on the validity and reliability of self-report measures. In particular, common method variance is a potential concern in all studies that rely on self-reporting methods (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003; Razavi, 2001). Defined as variance that is attributable to the measurement method rather than to the constructs the measures represent (Podsakoff et al., 2003), method variance may cause systematic measurement error that threatens the validity of the conclusions about the relationships among theoretical constructs (Podsakoff et al., 2003). While one way to address this problem is to include objective or independent measures of variables, this approach may sometimes not be feasible for practical and economic reasons. For example, in the case of the present work, objective measures of constructs such as ill health, absenteeism, or employee turnover are not easily obtained from all respondents because of confidentiality, privacy, and accessibility issues. Additionally, the use of this approach may require additional time, effort, and cost on the part of the researcher.

Acknowledging this issue, several procedural remedies, as outlined by Podsakoff et al. (2003), were applied to minimise common method variance in the present research. These include reducing item ambiguity, ensuring all measures were carefully designed, providing supplementary instructions regarding the methods of filling in the questionnaires, and giving the opportunity to clarify questions through face-to-face data collection. In order to minimise respondents' evaluation apprehension and make them less likely to edit their responses to be more socially desirable, respondents were assured that there are no right or wrong answers and that they should answer questions as honestly as possible (Podsakoff et al., 2003).

4.3.5 Data collection

Approval from the University of Nottingham Research Ethics Committee was first obtained prior to starting the work. Subsequently, the research was approved by the Economic Planning Unit, the Prime Minister's Department of Malaysia. Next, official letters and e-mails were sent to the Ministry of Transport, the Department of Railways, the Urban Transportation Department, Kuala Lumpur City Hall, Malaysian Railway (Keretapi Tanah Melayu Berhad: KTMB), Rangkaian Pengangkutan Integrasi Deras Sdn Bhd (RapidKL), and the Association for the Improvement of Mass Transit (TRANSIT) explaining the purpose of the research and requesting permission to conduct the two studies.

Having obtained cooperation from these organisations, questionnaires for the key stakeholder scoping survey were distributed by e-mail to the related stakeholders. Given the comprehensive nature of the questionnaire, all stakeholders were given adequate time to complete the forms. No compensation was given to individual respondents for their participation in this study. However, letters of appreciation were sent to each stakeholder institution after the completion of the research.

Data collection for the second phase of the research (the Passenger Survey) started with identification of the survey area. Using the strategy for identifying the likely catchment areas recommended by the UK GMPTE Research and Intelligence (2006), the questionnaires for this survey were distributed to organisations that are located within the survey area of 800 metres around each selected rail station (see Section 7.4.2 of Chapter 7 for further elaboration). Forty-nine enumerators, who received an extensive training session on questionnaire administration, were employed to distribute and collect the questionnaires within the survey area. Each respondent received a pack containing the following items: (1) a participant information leaflet which explains the purpose of the study and the confidentiality guidelines to which the study adheres, (2) a copy of the questionnaire, and (3) information on how to contact the researcher should they need more clarification about filling in the forms. Respondents were given four weeks to complete and return the questionnaires in a sealed envelope, after which they were collected personally by the enumerators.

All respondents who completed the questionnaire in the second study received an honorarium of MYR20.00 (equivalent to £4.18) for their participation. Although studies have shown that monetary incentives can significantly improve response rates and reduce follow-up costs (Edwards et al., 2007; Paul, Walsh, & Tzelepis, 2005), the honorarium offered in this study was not intended to be the only motivating factor to recruit participants. Rather, it was solely intended as a symbolic gesture in recognition of the contributions that these individuals made to this research.

4.3.6 Data analysis protocols

Data from the key stakeholder scoping survey were analysed using the five predetermined themes covered in the questionnaire. The themes were used because of their documented relevance in the rail literature as important areas of consideration. This technique is suitable to answer the research questions that have been posed for two reasons. First, it enables us to obtain and examine logistics, management, and operation data from the stakeholders, most of which are not available in the public domain. Second, information gathered and analysed in this study allowed us to use these data as a starting point, but not a constraint, for data collection and analysis in the subsequent study.

Both descriptive and multivariate statistics were computed on the quantitative data of the passenger survey with the aid of the Statistical Package for the Social Sciences (SPSS) for Windows version 16.0. For instance, descriptive statistics (means, standard deviations, and frequencies), exploratory factor analysis, and Multivariate Analysis of Variance (MANOVA), as well as correlation and regression analyses were performed. These analyses are described in detail in Chapters 6 and 7.

To answer Research Question One, which explores the possible psychological components that construct the experience of crowding, specific analyses were conducted; including content validity ratio (CVR), principal axis factoring (PAF), confirmatory factor analysis (CFA), indicator reliabilities, composite reliabilities, variance extracted estimates, convergent validity, and discriminant validity. The data were also subjected to SEM to test the hypotheses and the overall model. SEM is a statistical methodology for representing, estimating, and testing a series of relationships between variables (Byrne, 2009). This analytical method is appropriate for the purpose of the present research and the type of data being collected due to its capability of assessing complex relationships and patterns between multivariate data in a single, systematic, and comprehensive manner (Gefen, Straub, & Bourdreau, 2000).

Meanwhile, path analysis testing via SEM was conducted to examine Research Questions Two and Four. The path analysis approach (Wright, 1934) was undertaken for three reasons: (1) all variables were manifest rather than latent, (2) the analysis allows the confirmation of a hypothesised model and the drawing of inferences from this model rather than just an exploration of the data, and (3) its tests of fit allow implausible models to be rejected (Byrne, 2009; Gefen et al., 2000).

In all SEM and path analyses, Maximum Likelihood (ML) estimation was used to examine model fit for the reported values of the fit indices and estimates for the paths of all models tested. This method was chosen because it is relatively stable against violation of normality in large samples (Byrne, 2009; Bentler, 1992). The Analysis of Moment Structures (AMOS) version 16.0 software was selected to perform these modelling calculations because of its user-friendly programming language and its ability in handling datasets with non-normal distributions or missing values. In addition, when a variety of variables are examined, AMOS enables the estimation of both measurement and structural equations contained within the model while simultaneously being able to determine the goodness-of-fit of the specified model (Byrne, 2009).

The data collected for Research Question Three, which asks how well crowding experience and passenger density predict stress and feelings of exhaustion after controlling for demographic variables and individual psychological differences in commuting experience, were analysed using hierarchical multiple regression. Two separate analyses were computed for the respective outcome variables of the experience of stress and feelings of exhaustion.

Finally, data derived from the free-text responses to both questionnaires were examined for themes relating to potential initiatives aimed at mitigating the effects of rail passenger crowding. This analytical technique appears to be an appropriate tool to investigate Research Question Five, mainly because it enables the categorisation of passengers' ideas and opinions into meaningful themes.

4.3.7 Ethical considerations

All studies reported in this thesis have been reviewed and approved by the University of Nottingham Research Ethics Committee (Reference Number: November 7th, 2008) and the Economic Planning Unit, the Prime Minister's Department of Malaysia (Research Clearance Reference Number: UPE: 40/200/19/2410). In addition, the permission to use questionnaire materials which are not available in the public domain was sought from the respective authors (Professor Gary Evans, Professor Richard Wener, and Professor Avraham Kluger) prior to commencing the studies.

By returning the questionnaire, the respondents gave their informed consent for inclusion in the research and provided permission to disseminate the results for scientific purposes. Other measures that have been taken to address the key ethical issues include the use of a participant information sheet, safe storage, and careful screening of identification information to preserve the confidentiality of the participants.

The questionnaire used in the passenger survey asked the participants' age and other demographic questions, including their names and contact details. All this information was specifically requested for follow-up and payment purposes. In order to safeguard confidentiality, all original sources of data concerning the study were kept in a secure filing cabinet and access to all data files was restricted only to the researcher. These materials will be retained for at least seven years from the date of final publication which is based upon them in accordance with the University of Nottingham Code of Research Conduct and Research Ethics (2009).

4.3.8 Summary of rationale for research design and analysis

In summary, the present research employed both descriptive and quantitative, correlational field study designs. Such an eclectic design has gained momentum in recent years, particularly in rail-related studies. Data for the descriptive study were gathered from scoping questionnaires that were sent to key stakeholders in the Malaysian rail industry. This information was then used to provide some insights into the background issues and challenges faced by the industry. Meanwhile, data for the quantitative, correlational field study were collected from commuters by questionnaire survey and explored using a series of statistical techniques, including exploratory and confirmatory factor analysis, reliability and validity analysis, and regression models. In order to examine the patterns of the relationships among the different psychological components of crowding and their direct and spillover effects on commuters, statistical modelling using path analysis technique with a software program such as AMOS is regarded as fit for purpose and appropriate.

Altogether, Table 4.2 presents the relationships between the research questions, hypotheses, and survey questions in their respective data collection methods. The key stakeholder scoping study set the context and background for the passenger survey but did not determine the latter’s contents. The integration of both methods provides richness and detail to the research work and expands the scope of the thesis (see Figure 4.1).

Table 4.2.

Linking the research questions and hypotheses with the questionnaires

RESEARCH QUESTION (RQ)	HYPOTHESES	SURVEY QUESTION (SQ)	
		Key stakeholder scoping survey	**Passenger Survey**
RQ1: What are the possible psychological components that construct the experience of crowding?	**H1a:** It is hypothesised that the experience of crowding is constructed by three different psychological components: (1) affective reactions to the crowded situation, (2) evaluation of the psychosocial aspects of the crowded situation, and (3) evaluation of the ambient environment of the crowded situation. **H1b:** The measurement model assumes that the three components are intercorrelated, that each item loads on one and only one factor, and that the measurement errors are not correlated with one another.		Part 2: q7b q8b q9b q10b
RQ2: How and in what direction does the relationship between the experience of crowding and passenger density affect stress and feelings of exhaustion?	**H2a:** Commuters' evaluation of the psychosocial aspects of the crowded situation will be positively related to their affective experience of crowding. **H2b:** Commuters' evaluation of the ambient environment of the crowded situation will be positively related to their affective reactions to the crowded situation. **H2c:** Rated passenger density will be positively related to commuters' affective reactions to the crowded situation. **H2d:** The affective experience of crowding will significantly predict passenger stress. **H2e:** The affective experience of crowding will significantly predict feelings of exhaustion.	Part 4: q1: What are your organisations specific issues and concerns regarding rail passenger services? q2: How important is passenger crowding to the organisational issues identified?	Part 2: q7b q8b q9b q10b Part 2 (C): SACL - Stress Part 5 (I): GWBQ – Worn-out

(continued)

Table 4.2. (continued)

RESEARCH QUESTION (RQ)	HYPOTHESES	SURVEY QUESTION (SQ)	
		Key stakeholder scoping survey	Passenger Survey
RQ3: How well does crowding experience and passenger density predict stress and feelings of exhaustion?	**H3:** The different psychological components of crowding will be positively related to the experience of stress and feelings of exhaustion, after controlling for demographic variables (gender, age) and individual psychological differences of the commuting experience (predictability, personal control, personal space, negative mood, effort expenditure, coping).		Part 3 (D): Journey in general
RQ4: How does the crowding experience (together with passenger density) affect the home and work life of commuters?	**H4a:** High experience of stress and feelings of exhaustion, as attributed by the joint contributions of crowding experience and passenger density will be related to a greater number of reports of somatic symptoms of ill health and decreased life satisfaction. **H4b:** High experience of stress and feelings of exhaustion, as attributed by the joint contributions of crowding experience and passenger density will be related to decreased job satisfaction, increased intention to quit, and higher rates of lateness and absenteeism at work.		Part 3 (E): Somatic symptoms Part 4 (F): commuting-related lateness and absenteeism Part 4 (G): Intention to quit Part 4 (H): MSQ Job Satisfaction Part 5 (J): SWLS Life Satisfaction

(continued)

Table 4.2. (continued)

RESEARCH QUESTION (RQ)	HYPOTHESES	SURVEY QUESTION (SQ)	
		Key stakeholder scoping survey	**Passenger Survey**
RQ5: What interventions are required to resolve issues associated with rail passenger crowding and would these measures correspond to interventions proposed by Cox et al.'s model (2006)?	**H5:** It is hypothesised that while engineering interventions would be seen as part of the solution to crowding issues in the rail industry, psychologically oriented interventions would also be viewed as effective and beneficial in guiding the development of a broader crowding management policy and planning.	Part 4: q1: What are your organisation's specific issues and concerns regarding rail services? q2: How important is passenger crowding to these issues? Part 5: q1: Do you have any plans to expand over the next five years? q2: What would you say are the biggest challenges facing train operating companies at the moment? q3: What could be done to overcome some of the barriers you have identified? q4: What could your organisation do to facilitate these efforts, especially in terms of crowding issues?	Part 1: 11a Part 6 (Comments)

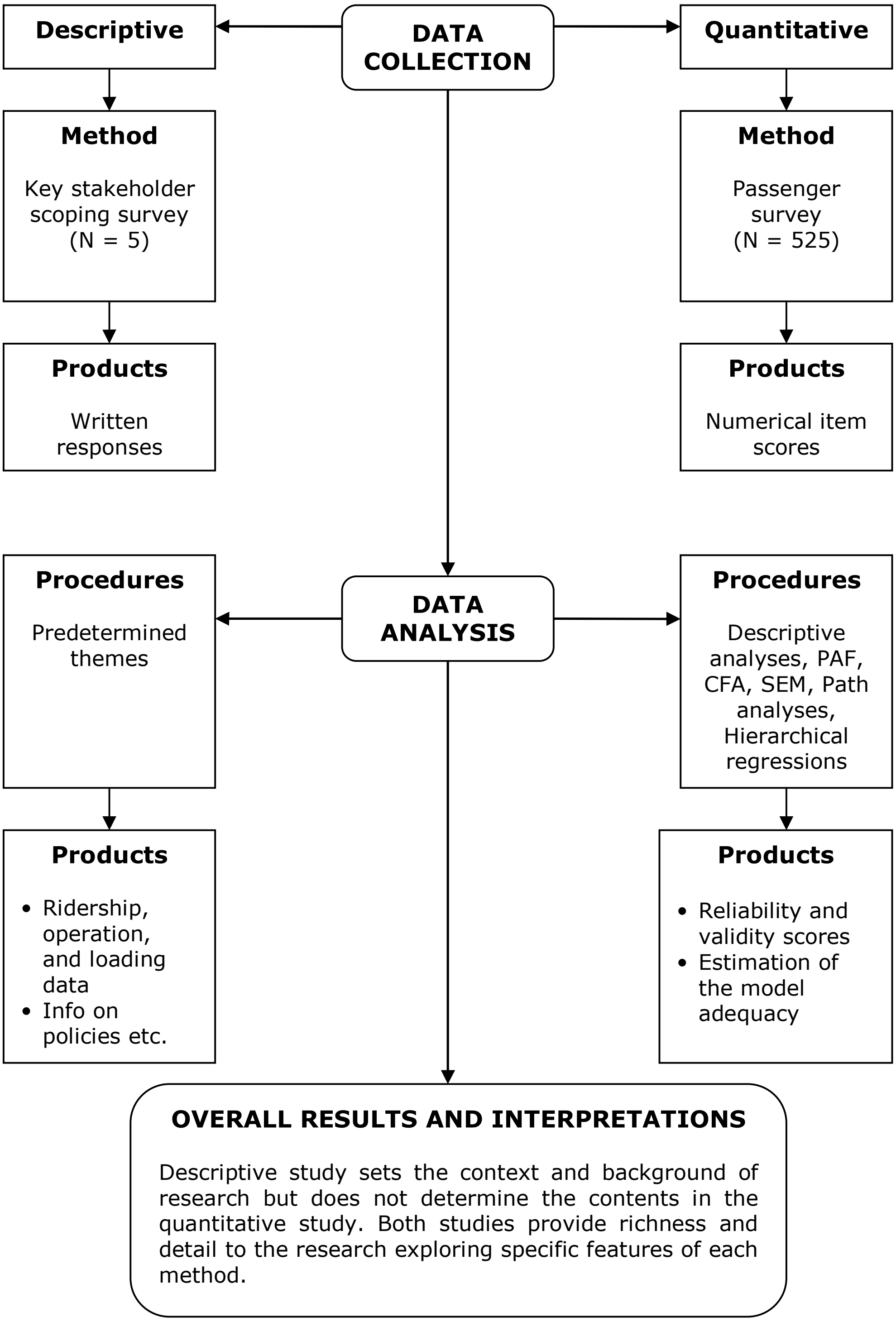

Figure 4.1. Visual diagram of procedures followed in the present research.

4.4 Chapter summary and conclusions

The chapter has presented an in-depth discussion of the differences between possible research methodologies and, on the basis of this, made an argument for the methodologies chosen. Given the nature and range of research questions that must be addressed, an eclectic research design was adopted, utilising both descriptive and cross-sectional, correlational field studies as appropriate. A large portion of the chapter was also given over to an explanation of the research design and practical issues in conducting the present work. Additionally, the procedures taken to ensure that ethical issues were fully dealt with have been presented and discussed. The next chapter proceeds to describe the results of the first phase of the research programme (the key stakeholder scoping study) while findings from the passenger survey are discussed in Chapters 6 and 7.

CHAPTER 5 – KEY STAKEHOLDER SCOPING SURVEY

5.1 Chapter overview

This chapter reports the first phase of this research programme, which focused primarily on the issues affecting the rail industry in Malaysia. In this phase, a key stakeholder scoping survey was conducted for three reasons. First, it provides essential background data for this thesis in relation to the Malaysian rail industry; second, it justifies the selection of the research location; and third, it informs us about the perceptions of the key stakeholders in the rail industry with regards to the issue of passenger crowding and their specific concerns regarding the overall rail passenger services. The principal research question to which this study contributes is Research Question Five (RQ5), but Research Question Two (RQ2) is also addressed.

The first part of the chapter explains the local conditions in which the rail passenger services in Greater Kuala Lumpur and Klang Valley operate. It also describes the operation and management of the four rail services of interest in this study. The second part of the chapter discusses the objectives of the study. Using an open-ended questionnaire, data were gathered from organisations identified as having a stake in the Malaysian rail industry. Five stakeholders, who included representatives of governing and rail regulatory bodies, rail operators, and a public transport advocacy group, responded to the survey. The findings of the study are reported according to five themes: (1) ridership statistics, (2) reliability and service quality data, (3) passenger load and train capacity, (4) challenges and constraints faced by the rail industry, and (5) future plans to address the specified challenges and concerns. The chapter ends with some interpretations of the results in light of the study's research questions and conceptual framework.

5.2 Introduction

In this section, the background information of the existing rail passenger services in Greater Kuala Lumpur and Klang Valley is examined. An understanding of this information is necessary, as the background profile helps to define, in general terms, the local conditions in which the light rail transit (LRT) and commuter rail services of interest operate. In addition, this section also discusses the current approach and management adopted in the Malaysian rail industry.

5.2.1 Travel demand growth and commuting pattern

Strategic transport infrastructure and policy planning in Malaysia, particularly in Greater Kuala Lumpur and Klang Valley, have been inadequately addressed in the past, and this scenario has led to traffic congestion, pollution, noise, and, to some extent, accidents (Ensor, 2004; Mody, 1997). A comprehensive framework of transportation management with a particular focus on planning, policies, and regulations of public transportation system operations remains less than adequately addressed by current systems of public provision. The Malaysian government has initiated several efforts since the 1970s to study public transportation problems, which include a proposal for rail mass transit in Kuala Lumpur (Malaysian Business, 1977 cited in Townsend, 2003). However, the plan, which was scrutinised by a US-based consultant working for the World Bank, did not materialise as the consultants were in favour of motorisation, road building, and a traffic limitation strategy (Wilbur Smith and Associates, Llewelyn-Davies Weeks, Forestier Walker & Bor, & The SGV Group, 1973). The report does not only advise the government to reconsider its plan to pursue rail development but it even suggests that abandoned rail lines be converted into bus lanes.

Following these suggestions, pro-motorisation strategies were adopted, while planning for future rail systems in the metropolitan area was postponed (Townsend, 2003). Most of the resultant initiatives implemented at present are in favour of private car usage and do not entirely solve the overall planning and coordinating problems of urban transportation. For instance, the continued construction of urban road projects, the completion of the Integrated Transport Information System (ITIS) which conveys real-time information on traffic situations, and the completion of the Stormwater Management and Road Tunnel (SMART) project which is designed to ease traffic congestion and mitigate flash floods in Kuala Lumpur, somewhat promote automobile dependency rather than multi-modal transport systems.

Several other factors such as population and employment growth, rising incomes, increased female participation in the workforce, increased size of the working age group, and growth of the suburbs have been found to drive travel demand growth in Malaysia (Ensor, 2004). In particular, these factors create greater demand during peak hours and contribute to increased commuting times and traffic congestion. For example, in the case of workers in Kuala Lumpur, commuting durations of between 29 and 45 minutes per day either by public or private transport is not uncommon for individuals (Regus, 2011), with the most pronounced peak times at 7:00 a.m., 1:00 p.m. and 5:00 p.m. While about 17% of commute trips depart at around 7:00 a.m., there is also an earlier morning peak at 6:00 a.m. owing to sprawl or congested or unpredictable traffic (Hyodo, Montalbo, Fujiwara, & Soehodho, 2005).

On average, commuters make slightly more than two trips per day, with the distribution of trip purposes spanning over commuting to home, work, and school (Hyodo et al., 2005). Studies by Nielsen Malaysia Research (2009) on bus riders and Keretapi Tanah Melayu Bhd (KTMB) Customer Satisfaction Survey (2004) on rail commuters found that most commuting trips were made by students and working adults (that is, for educational and occupational reasons), while only a small percentage of trips were reported to be for other purposes. More than 50% of commuters in Kuala Lumpur are male, who make three or more trips per day, while fewer females are observed to commute (Hyodo et al., 2005). In general, people between 21 to 40 years old make the greatest percentage of trips and are the group who most often make more than three trips per day (Hyodo et al., 2005).

The trend of motorisation has become a critical issue in Malaysia. Although not yet considered as a highly automobile-dependent country, Malaysia is now in the stage of being "moderately traffic-saturated" (Barter, 2004). The number of newly registered motor vehicles in Kuala Lumpur alone was 537,092 in 2008 and 513,954 in 2009 (Road Transport Department, 2010). It is projected that Malaysia will rapidly reach a vehicle ownership of 200 vehicles per 1000 people at a relatively low income level and will surpass the estimated maximum saturation level of 827 vehicles per 1000 people (Dargay, Gately, & Sommer, 2007).

With the rise in automobile use, public transportation remains secondary in commuting choice. The present modal split of public to private transportation is about 20:80 (Sharifi et al., 2006). Only 16% of Klang Valley residents use public transport, whereas on any given day, about 1.5 million single-occupancy vehicles are driven to and from jobs in the city centre (Keat, 2009). This situation is further aggravated by the lack of formal, comprehensive planning and policy formulation for public transport in Malaysia. Findings from a study of transportation and the environment in Kuala Lumpur strongly emphasise the need for the government to establish a new organisation for urban transport coordination, as none of the existing entities could consider this issue from a regional perspective (Pacific Consultants International & Suuri-Keikaku Co. Ltd, 1999). A number of more recent studies echo a similar need and conclude that until such a plan is established and functionally in place, transportation and commuting issues in Greater Kuala Lumpur and Klang Valley will remain unresolved (for example, see Ahmad, 2010; Zakaria, 2003).

5.2.2 Greater Kuala Lumpur and Klang Valley rail networks

The Greater Kuala Lumpur and Klang Valley area, which covers Kuala Lumpur, Putrajaya, Petaling, Klang, Gombak, Hulu Langat, and Sepang as well as Rawang and part of Negeri Sembilan, is served by a number of different rail transportation service providers. This includes Rangkaian Pengangkutan Integrasi Deras (RapidKL) for LRT services, Malaysian Railway or Keretapi Tanah Melayu Bhd (KTMB) for commuter and interstate rail services, KL StarRail Sdn Bhd for monorail services, and Express Rail Link Sdn Bhd for high-speed rail services. The LRTs and monorails are typically used for urban public transport and some special use such as transporting passengers between airport buildings, while commuter and high-speed rail are mostly used for intercity passenger rail services. This section only describes the rail services included in the study; therefore detailed descriptions of monorail, high-speed, and interstate services are not discussed here. All information reported in this section as well as in Section 5.2.3 were obtained from the respective organisations' websites unless otherwise stated.

5.2.2.1 *Kelana Jaya line*

The LRT Kelana Jaya line began its operation in June 1999 and today services routes between the north-eastern suburbs of Kuala Lumpur and the urbanised corridor of Petaling Jaya and Kelana Jaya, which are located to the west of Kuala Lumpur. The line, formerly known as PUTRA LRT (Projek Usahasama Transit Ringan Automatik Sdn Bhd), is one of the longest driverless automated metro systems in the world. It has 24 stations (five stations underground, 18 elevated, one at-grade) along its 29 km length and currently operates with 35 two-car Bombardier-manufactured Advanced Rapid Transit (ART) MK II train sets. With an average train speed of 40 km per hour, the total travel time between Kelana Jaya and Gombak is approximately 45 minutes each way. The line, which operates 18 hours a day for seven days per week, carries 170,000 passengers a day and over 350,000 a day during special events.

5.2.2.2 *Ampang line*

The Ampang line, which is a driver-operated light rail transportation system, transports passengers from the northern, north-eastern, and south-western suburbs of the Klang Valley to Kuala Lumpur city centre. First operated in December 1996 under the name of Sistem Transit Aliran Ringan Sdn Bhd (STAR LRT), this system began its commercial service between Ampang and Jalan Sultan Ismail, covering a distance of 12 km with 14 stations and operating at a daily frequency of 5 to 15-minute intervals. The construction of the second phase of the system was completed in 1998 and consists of a 12 km extension from Chan Sow Lin station in Kuala Lumpur to Sri Petaling, and a 3 km extension from Sultan Ismail to Sentul. Altogether, the line uses six-cars, Adtranz standard-gauge, electric multiple unit (EMU) train sets, and transports approximately 150,000 passengers daily throughout 25 stations covering 27 km of track.

Both the Kelana Jaya and Ampang lines are operated by a government-linked company, namely the Rangkaian Pengangkutan Integrasi Deras (RapidKL), while the assets are owned by Syarikat Prasarana Negara Bhd (SPNB). The two lines make up about 65% of the public transportation in Kuala Lumpur and complement the bus and other rail services[2].

5.2.2.3 KTM Komuter

The KTM Komuter service, which is operated by the Malaysian Railway or KTMB, covers about 217 km of track with 51 stations connecting outlying Klang Valley suburbs and townships with the city centre and major employment locations in Kuala Lumpur. This electrified commuter train service was first introduced in 1995 and currently consists of two lines, namely the Sentul-Port Klang and Rawang-Seremban lines as well as a shuttle service from Rawang to Tanjung Malim. Whilst the routes for Kelana Jaya and Ampang lines tend to have short running times, the KTM Komuter routes are much longer and take more time to complete a trip because they cover a greater distance from the suburbs to the city centre. The total travel time for a KTM Komuter train to travel from Sentul to Port Klang is approximately 81 minutes, while the longer journey from Rawang to Seremban takes

[2] Further information on the Kelana Jaya and Ampang lines can be obtained from RapidKL's website at http://www.myrapid.com.my/ and SPNB's website at http://www.prasarana.com.my/assets/index.html.

approximately 125 minutes to complete. Since its inception, daily KTM Komuter ridership is averaging 90,000 passengers per day[3].

Figure 5.1 presents the urban rail network in Greater Kuala Lumpur and Klang Valley, while Table 5.1 summarises the specification of the services provided by each rail operator surveyed in the study.

[3] Descriptive information on KTM Komuter's history and services, including its extension plans, can be found on the operator's main website at http://www.ktmkomuter.com.my/index.php.

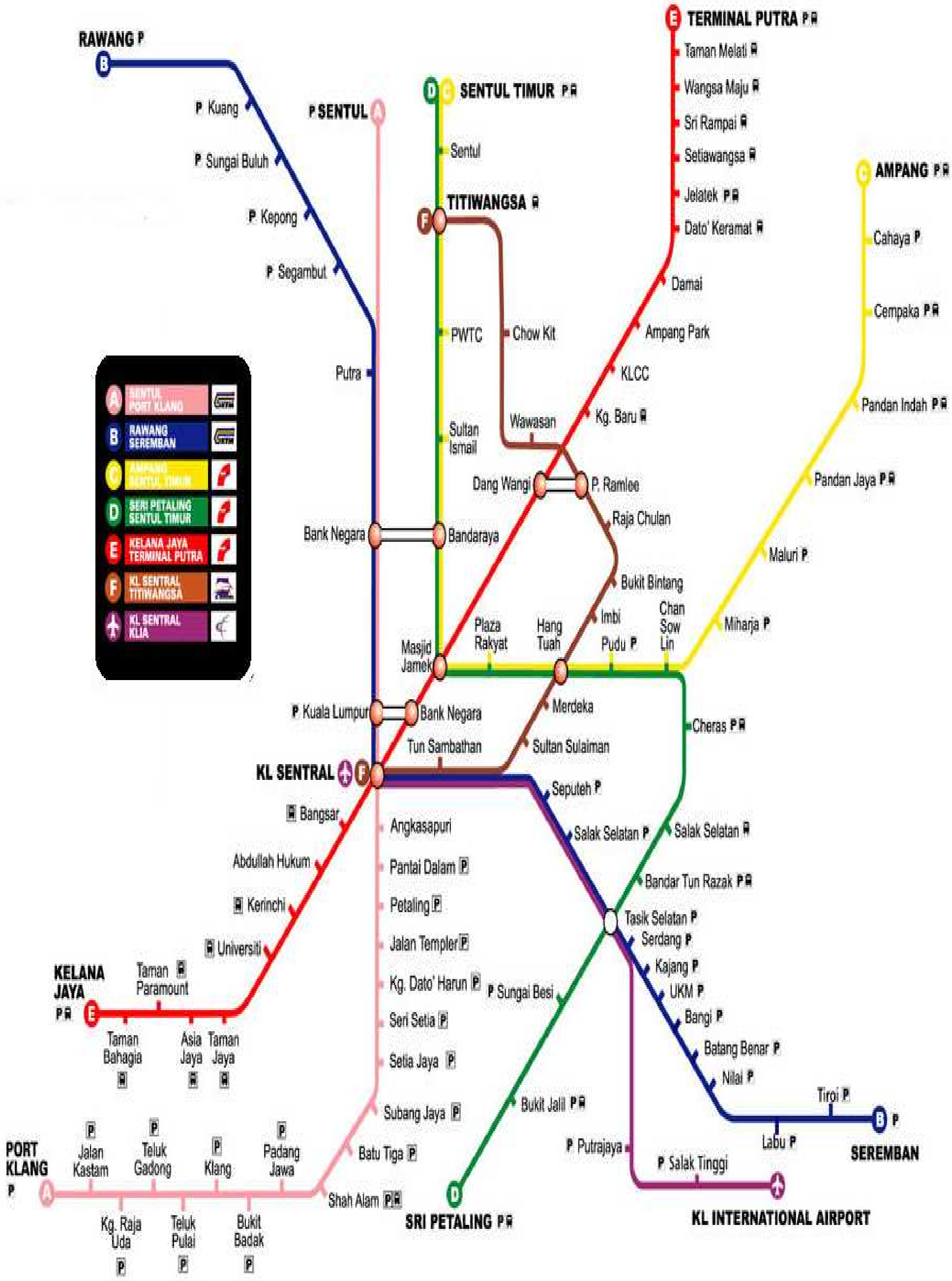

Figure 5.1. Greater Kuala Lumpur and Klang Valley urban rail network. Adapted from http://www.prasarana.com.my/assets/route.html

Table 5.1.

Specification of the rail services surveyed in this study

Rail line	Operator	Ownership	System	Service area	Days and hours of operation	Total travel time (mins)
Kelana Jaya	RapidKL	Syarikat Prasarana Negara Berhad (SPNB)	24 stations, 29km ART Mark II light rail transit	Gombak - Kuala Lumpur - Petaling Jaya	Monday-Saturday: 6:00–11:50 pm Sunday: 6:00–11:30 pm	45
Ampang	RapidKL	Syarikat Prasarana Negara Berhad (SPNB)	25 stations, 27 km, Adtranz light rail transit	Sentul - Kuala Lumpur - Ampang/Sri Petaling	Monday-Sunday: 6:00–11:30 pm	31
KTM Komuter Sentul-Port Klang	Keretapi Tanah Melayu Bhd (KTMB)	Railway Assets Corporation (RAC)	27 stations, 52 km, electric multiple unit (EMU) trains	Sentul - Kuala Lumpur - Petaling Jaya Selatan - Shah Alam - Klang - Port Klang	Monday – Sunday 5:48 am–12:00 am	81
KTM Komuter Rawang-Seremban	Keretapi Tanah Melayu Bhd (KTMB)	Railway Assets Corporation (RAC)	24 stations, 153 km, electric multiple unit (EMU) trains	Kuala Kubu Bharu - Rawang - Kepong - Kuala Lumpur – Kajang - Nilai – Seremban	Monday – Sunday 5:48 am–12:00 am	125

5.2.3 Administration and coordination of rail services

The Greater Kuala Lumpur and Klang Valley rail network was developed by different companies at different times. Although each alignment was designed with a passenger rail service in mind, the original rail operators were generally competing with each other for passengers. At present, the LRT, commuter, monorail, and high-speed rail services are still operating independently. As a result of this approach, the existing rail services are not fully integrated with each other in terms of physical infrastructure, ticketing services, and service routes.

There is yet a single agency to oversee the overall transport planning and regulation in Malaysia, including those related to rail. Although the Ministry of Transport, under its Land Division, is responsible for formulating policies, coordinating developmental aspects of rail-based transport, and maintaining the overall transportation network, it is not generally involved in the process of network planning and development. Similarly, the Department of Railways (DOR) is responsible for enforcing regulations and ensuring compliance with safety standards, but it is not directly involved in rail operations. The Urban Transportation Department, Kuala Lumpur City Hall, however, exercises its functions only at the local level. Meanwhile, the Ministry of Finance owns the two government-linked companies, SPNB and RapidKL, which build and operate transit services. However, neither organisation has the authority to regulate service at a local level. As there is no single clear chain of hierarchical authority in the rail sector, individual public and private corporations tend to initiate uncoordinated transit projects, resulting in increased competition for passengers, exacerbation of the overcapacity problem, different ticketing systems, and, to some extent, service quality deterioration (Ahmad, 2010).

Large-scale efforts in regulatory restructuring and establishing a single authority accountable for policy planning and regulatory oversight of public transport have been taken up only recently in 2009. Under the Government Transformation Programme (GTP), public transportation improvement was included as one of the six National Key Result Areas (NKRA) outlined, and two entities were established to realise this objective. First, a formal cross-agency team, named the Urban Public Transport (UPT) Lab, was formed to formulate the targets, timelines, and initiatives for identifying possible improvements in the country's public transport system. The specific aims of the lab are to (1) increase the public transport mode share to 13% in 2010 and to 25% by 2012 during the morning peak hours of 7:00 – 9:00 a.m. in Klang Valley, followed by separate plans to improve public transport in other states; (2) improve reliability and journey times; (3) enhance comfort and convenience; and (4) improve accessibility and connectivity such that the percentage of the population living within 400 metres of a public transport route is increased from 63% to 75% in 2012.

Second, the Land Public Transport Commission (LPTC) or Suruhanjaya Pengangkutan Awam Darat (SPAD) was established in June 2010 with a mandate to plan, regulate, and enforce rules concerning land-based public and freight transport in Malaysia, as required under the NKRA. The Commission's tasks include: (1) developing strategic and master plans for public transport development at the national and regional level; (2) monitoring and regulating the standard of performance of operators through licensing; and (3) carrying out enforcement work detailed in the Land Public Transport Act 2010, which includes the powers to audit, investigate, suspend and revoke license, seize vehicles, and penalise operators. One of the most significant changes impacting railways is the transfer of railway functions from the Department of Railways (DOR) to the Commission. Under the Land Public Transport Act 2010, functions such as submission and verification of railway schemes, issuance of railway licenses, approval of the opening of new railways, periodic inspections and project monitoring, and management of railway protection zones will be taken over by the Commission[4].

Although the large-scale initiatives were in place, some regulatory issues remained unresolved, resulting in a delay of both the implementation of the new law and full mobilisation of the LPTC. The Land Public Transport Act 2010, which has not come into force due to the delay in acquiring Parliamentary approval, requires amendments to several other Acts before it is passed into law. Until the amendments to these Acts are passed by the Malaysian Parliament, the Commission does not have full authority to function as a single entity for managing public transport. At the time of writing, all relevant Acts are still waiting to be gazetted.

5.3 The current investigation

Having discussed the commuting patterns and background of the passenger rail network in Greater Kuala Lumpur and Klang Valley, it is imperative to state that the objectives of the current study were: (1) to gather key stakeholders' perceptions of rail passenger crowding, (2) to investigate what kind of issues the key stakeholders had about rail passenger services as a whole and how they would address these issues, and (3) to collect information on the future plans and possible interventions that the key stakeholders will make to resolve the issues associated with rail passenger crowding. Information collated from this study was crucial for the subsequent empirical work because it

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[4] Further information about the UPT Lab and LPTC are available at http://www.pemandu.gov.my/gtp/?page_id=39 and http://www.spad.gov.my/ respectively.

provided the background data of the rail lines selected and offered information about the utilisation of those services by the commuters.

5.4 Method

5.4.1 Participants

Stakeholders are broadly defined as persons or groups that have or claim ownership, rights, or interests in a corporation and its activities (Clarkson, 1995). Within the rail industry, there are basically two types of stakeholders: (1) primary stakeholders, who are likely to affect and be affected by the issue or a potential response to it, for example governments, rail operators, regulatory authorities, commuters, shareholders, rail suppliers, and manufacturers; and (2) secondary stakeholders, who are the intermediaries in the process but not essential to the survival and well-being of the industry, for example monitoring and advocacy organisations and non-governmental organisations.

The key stakeholders recruited in this study were Malaysian governmental and rail regulatory bodies such as the Ministry of Transport, the Department of Railways, and the Urban Transportation Department, Kuala Lumpur City Hall. Two rail operators were also consulted, including Malaysian Railway (KTMB) and RapidKL as well as a non-governmental organisation representing public transport users, namely the Association for the Improvement of Mass Transit (TRANSIT). Characteristics and justifications for the selection of the key stakeholders are summarised in Table 5.2.

Table 5.2.

Characteristics and justifications for selection of the key stakeholders

Stakeholder	**Major functions**	**Justifications for selection**
Land Division, Ministry of Transport Malaysia (MOT)	• Formulates policies, undertakes research, and coordinates infrastructure development plans in the rail transport sector. • Conducts necessary enforcement according to the Railway Act 1991 and reviews laws of rail-based transport. • Regulates the rates and fares of railway operators.	Selected because of its involvement in policy and planning as well as coordination and enforcement functions in rail-based transport.
Department of Railways (DOR)	• Regulates railway operations and services. • Studies proposals for new railway schemes and makes recommendations to the MOT. • Prescribes minimum safety standards for railway operations and ensures compliance with safety standards. • Prescribes registration and minimum qualifications for railway officials. • Promotes public interest in terms of fares and tariffs, standards, and quality of services.	Selected because of its involvement in policy and planning as well as coordination and enforcement functions in rail-based transport.

(continued)

Table 5.2. (continued)

Stakeholder	Major functions	Justifications for selection
Urban Transportation Department, Kuala Lumpur City Hall	• Coordinates and manages the implementation and construction of rail systems (Monorail, Ampang line, Kelana Jaya line, KTM Komuter) and the town highway in Kuala Lumpur. • Manages and maintains the operations of railway station car parks and other public parking in Kuala Lumpur. • Plans, coordinates, and manages public transport facilities in Kuala Lumpur. • Provides advisory services and expertise on the planning and implementation of urban transportation systems and urban traffic management systems.	Selected because of its involvement in policy and planning as well as coordination and enforcement functions in rail-based transport.
Keretapi Tanah Melayu Berhad (KTMB) or Malaysian Railway	• Provides commuter, intercity, regional, and freight railway services. • Owned by the Malaysian government; its assets are owned, managed, and maintained by the Railway Assets Corporation (RAC), a federal statutory body under the Ministry of Transport.	Selected because it operates commuter rail lines of interest in the study.

(continued)

Table 5.2. (continued)

Stakeholder	Major functions	Justifications for selection
Rangkaian Pengangkutan Integrasi Deras Sdn Bhd (RapidKL)	• Operates the LRT services (Ampang and Kelana Jaya line) and almost half of the bus services in Kuala Lumpur. • A subsidiary of SPNB; both are wholly owned government companies established by the Ministry of Finance.	Selected because it operates light rail lines of interest in the study.
The Association for the Improvement of Mass Transit (TRANSIT)	• Acts as a pressure group for public transport users. • Ensures the voice of the passenger is heard in public transport planning, regulation, and operation. • Encourages campaigning and advocacy for improved public transport.	Selected because of its interest in improving the public transport system in Malaysia.

5.4.2 Data collection

The views of the six key stakeholders were sought via an emailed questionnaire, which contained five categories of open–ended questions. Official letters were sent to the relevant personnel in each stakeholder institution, requesting the designation of a contact person for follow-ups and the protocol for distributing the questionnaire. Having obtained the stakeholders' cooperation, the questionnaire was then distributed by e-mail with a request to return it duly filled in.

The method of collecting data electronically is increasingly used in various academic studies, partly because of its relative speed and low cost in data collection (Reynolds, Sharp, & Anderson, 2009). For these reasons, and given that there is a general growing trend of computer and Internet usage in Malaysia, this method was considered suitable for collecting the relevant data from the identified stakeholders. One major disadvantage of this method, however, is that the absence of the researcher may render the responses less reliable, as there is no one physically present to clarify any confusing questionnaire items. This limitation was addressed in this study in three ways: (1) by ensuring that the language used in the questionnaire was clear and without any ambiguity, (2) by providing supplementary instructions regarding the methods of filling up the questionnaire, and (3) by providing information about how to contact the researcher should they need more clarification about filling in the forms.

5.4.3 Questionnaire

A questionnaire with open-ended questions was used to encourage a full expression of opinions and a more detailed response from the stakeholders. While the items of the questionnaire varied according to the nature of the stakeholder - that is, whether they are involved in regulation, management, or operation - the questionnaire generally focused on gathering information about five issues, including (1) ridership statistics, (2) reliability and service quality, (3) passenger load and train capacity, (4) perceptions of specific operational issues and concerns surrounding rail passenger services, and (5) strategic issues and future plans to address the specified issues and concerns. The questionnaire items are appended as Appendix D.

The first set of questions was primarily designed to gather information about ridership statistics. Five questions were asked, including: (1) "Can you provide us your ridership statistics?", (2) "Do you have individual route peak point ridership data?", (3) "Do you have riding counts or ride-checks?", (4) "Do you have any published standards or policies on passenger traffic that you can send us?", and (5) "Do you have any information about your passenger profile that you can send us?".

Items in the second part of the questionnaire were designed to gather reliability and service quality data. The questions were: (1) "Can you provide us data on the following items: frequencies of trains, number or percentage of delays, number or percentage of headways missed, number or percentage of trains cancelled, percentage of escalators and lifts out of service, and average waiting time?"; (2) "Are there any benchmarking studies comparing your line with overseas railways? If so, what do they show?"; and (3) "How do you rate the current service quality provided by your line (for example, in terms of reliability, punctuality, safety and security, travel comfort, and customer information)?"

Part three of the questionnaire asked about passenger load and train capacity. Questions were: (1) "How do you calculate the loading level of your rail system? Are there any guidelines or standards that you can send us on this?”, (2) Do you maintain data on peak-time crowding statistics? Can you provide us with this information?”, (3) “Do you measure the ratio ridership to capacity? If Yes, can you provide the ratio?”, and (4) “What is the rail transit capacity of your line? Is this determined by a formula?”.

Two questions in part four were designed to explore the key operational issues faced by the stakeholders. The questions were: (1) “What are your organisation’s specific issues and concerns regarding rail passenger services?” and (2) “How important is passenger crowding to these issues?”

Finally, key strategic issues and measures for mitigation were explored in part 5 using four questions: (1) “Do you have any plans to expand over the next five years?”, (2) “What would you say are the biggest challenges facing train operating companies at the moment? Are there any particular issues which are constraining the industry?”, (3) “What could be done (for example, by the government, customers) to overcome some of the barriers you have identified?”, and (4) “What could your organisation do to facilitate these efforts, especially in terms of crowding issues?”

5.4.4 Data analysis procedures

As discussed in Section 4.3.6 of Chapter 4, respondents’ written answers to the free-response format questionnaire were examined using the themes covered in the question route. Therefore, the data were analysed and presented within five themes previously determined to meet the objectives of the study.

5.5 Results

Views from six key stakeholders were sought; however, only five completed questionnaires were returned. While all stakeholders reported willingness to help with the research, only some volunteered additional useful information. One stakeholder (Urban Transportation Department, Kuala Lumpur City Hall) who did not respond to the survey, stated that it did not have the requested data, while representative of the Kelana Jaya line did not answer some questions, claiming that some of the information was either unavailable or commercially sensitive. For this reason, basic information on ridership, rolling stock, and other information of the Kelana Jaya line were obtained from other sources such as from the Department of Statistics, Malaysia to achieve complete survey listings.

In this study, stakeholders were asked to give their responses in free-text form. Five key themes were discussed based on the written responses of the stakeholders. These key themes were: ridership statistics (Section 5.5.1), reliability and service quality data (Section 5.5.2), passenger load and train capacity (Section 5.5.3), challenges and constraints faced by the rail industry (Section 5.5.4), and (5) future plans to address the specified challenges and concerns (Section 5.5.5).

5.5.1 Ridership statistics

The ridership statistics for rail services included in the study are presented in Table 5.3. Data were compiled from the written responses provided by the stakeholders and railway statistics from the Department of Statistics, Malaysia.

Table 5.3.

Ridership trends

Year	Passenger ridership		
	Kelana Jaya	**Ampang**	**KTM Komuter**
2000	44,517,903	28,426,201	19,154,197
2001	52,478,951	32,412,191	20,928,816
2002	54,423,246	33,471,344	22,084,124
2003	56,579,263	39,084,943	24,645,493
2004	57,729,970	43,353,513	27,381,423
2005	60,478,719	45,825,928	30,934,651
2006	56,747,145	49,890,246	34,974,974
2007	56,012,669	53,349,571	36,959,339
Average yearly growth (%)[5]	3.69	12.53	13.28

Ridership grew by 29.5% between 2000 and 2007. While all the rail lines have had considerable gains in ridership, KTM Komuter registered the highest percentage of passenger ridership, with an average yearly growth of 13.28%. Ridership for the LRT Ampang line has also gained momentum over the same period, with an average yearly growth of 12.53%. Meanwhile, the LRT Kelana Jaya line's ridership increased between 2000 and 2005 but slightly declined in the following years.

[5] Calculated as: $\{[(V_{present} - V_{past}) / V_{past}] * 100\} / N$ (number of years)

5.5.2. Reliability and service quality data

The routes operated by RapidKL and KTMB carry different volumes of passengers, thus the headways of these services vary from route to route. Some routes run as frequently as every three minutes during the peak periods, while others run at 30-minute intervals. The headways also vary by time of day, with shorter headways in the morning and afternoon peak periods, and considerably longer headways during the evenings and night-time periods as well as at the weekends. Table 5.4 shows the average train frequency for all lines.

Table 5.4.

Average train frequency

Rail line	**Average train frequency (mins)**		
	Morning and afternoon peak periods	**Non-peak periods and evenings**	**Night-time**
KTM Komuter Sentul - Port Klang	15	20	30
KTM Komuter Rawang - Seremban	15	20	30
Ampang line	5	11	13
Kelana Jaya line	4	6	14

When asked to evaluate the service quality provided by rail operators, DOR rated punctuality, safety, security, and travel comfort as good, whereas reliability and communication provision tended to be moderate. MOT rated the reliability and punctuality of all rail services as very good: KTM Komuter (93.96%); Kelana Jaya line (98.72%); and Ampang line (100.00%). Meanwhile, RapidKL rated these same aspects of their train service as excellent. KTMB reported that whilst punctuality of its commuter rail services was rated poor, safety tended to be good.

The other categories such as reliability, travel comfort, and communication provision were rated as moderate.

5.5.3. Passenger load and train capacity

The Kelana Jaya line has three minutes headway between trains with a maximum capacity of 33,400 passengers per hour per direction (pphpd), whereas the maximum passenger capacity on the Ampang line is 33,200 pphpd with 2.8 minutes headway. Using the occupancy rate of pax or seat per kilometre to measure passenger loading level, the KTM Komuter services are set to run at 20 minutes headway. Daily ridership for the services is currently about 95,021.15, with a maximum passenger load capacity of 10,000 pphpd.

The morning peak-hour passenger train loadings in 2008 is summarised in Table 5.5. The comparison of the loading levels of the three rail lines shows that both the Kelana Jaya line and KTM Komuter services were carrying passenger loads far beyond their designed capacity. For the Ampang line, little variability in train capacity and passenger loading was found to exist.

The responses from the governmental authorities (MOT and DOR) revealed that there are no statutory controls or policy initiatives aimed at determining a safe level of passengers on a train. However, all rail operators are regulated under the Railway Scheme by DOR to ensure that their vehicles' loading characteristics meet the maximum crush load requirement as per agreed design.

Table 5.5.

Morning peak-hour passenger train loadings in 2008

Rail line	Head-ways (mins)	Trains	Capacity (potential)	Utilisation AM peak	% loading	Reasonable spare capacity
Kelana Jaya	3	35 two-car train sets	33,400 pphpd	34,000	101.8	-600
Ampang	2.8	Six-car train sets (total rolling stock not available)	33,200 pphpd	26,560	80.0	6640
KTM Komuter	20	62 sets of three-car EMUs	10,000 pphpd	10,150	101.5	-150

Since the opening of the LRT and the commuter rail services, passenger ridership has been documented systematically by the relevant rail operators. In contrast to this, data for passenger traffic such as the number of passenger journeys and passenger kilometres travelled were not explicitly reported by all stakeholders. Data on peak-time crowding statistics are also not maintained centrally by either MOT or DOR. Nonetheless, passenger boarding and alighting counts of each rail service can generally be obtained from the relevant rail operators based on their auto-gate or turnstile counter statistics.

Both MOT and DOR reported that no benchmarking studies have been conducted to evaluate the relative performance of railway transportation in Malaysia, and data on the overall rail passenger profile are not centrally collected. Instead, each rail operator conducts their own independent survey to collate information about who is using their services. For example, KTMB reported that in its 2005 survey, the majority of its users were workers and students.

5.5.4. Challenges and constraints faced by the rail industry

When prompted about how big a problem passenger crowding currently is and how it affects the operational issues of the rail industry, KTMB, MOT, and DOR focused on issues of high patronage demands and shortage of rail capacity. As one stakeholder said, "*For the past two years, KTMB has been constrained with the inadequacy of sets availability to run more service to meet the growing demand. Currently we found that the train occupancies (seating and standing) during peak hours have exceeded the standard train capacity of 400 passengers per train.*" MOT reported that the high ridership versus limited capacity issue is a major concern for rail operators during peak hours, as they need to ensure that there are sufficient train sets available for the users. While MOT reported that the Kelana Jaya line and KTM Komuter services are especially affected by these problems, DOR estimated that about 60% of overall rail ridership is affected by these issues.

Both MOT and DOR reported similar issues affecting passenger crowding in the study. Besides the inadequate supply of trains for use during peak hours, other factors such as the lack of a well-integrated fare system also play a role. According to these stakeholders, crowds tend to build up at the ticket counters or ticket vending machines, particularly during festive or special events, and the different fare collection systems for each rail operator cause problems for users.

It is interesting to note that while most of the stakeholders consulted regarded passenger crowding as a fairly general, albeit growing problem, responses from the Ampang line representative showed that the crowding issue is considered small. Nonetheless, it appears that there is a strong focus on five operational issues that are deemed to be the principal challenges facing the rail industry across all stakeholders rather than overcrowding issues.

First, MOT and DOR reported that both the Ninth Malaysian Plan and the Malaysian ISO Standard 2005 include conditions which require each rail operator to make adjustments to the physical environment of their infrastructures in order to enable easy access for disabled passengers. More specifically, operators are required to provide facilities such as elevators, escalators, and tactile warning surfaces in all relevant parts of the railway to cater to the needs of disabled passengers. These requirements pose a challenge for the industry, as the vast majority of Malaysia's existing rail infrastructure has neither dedicated disabled access nor disabled-friendly features at their premises.

Second, there appears to be growing pressure on the government and rail operators to ensure that Greater Kuala Lumpur and Klang Valley have adequate rail capacity to meet the rising demand for urban rail travel. RapidKL expressed the view that "*increasing modal split in favour of public transport remains as the main challenge and capacity constraints will be difficult to match*". Both MOT and DOR highlighted the problems of supply and demand faced by rail operators due to an inadequate number of trains. These stakeholders believe that any demand for increased rail travel could be met by additions to the existing train capacity and expansions of the rail capacity. Train capacity could be added onto the existing rail services by procuring new train sets for LRT and commuter routes, increasing train frequency, and increasing train lengths. Meanwhile, rail capacity constraints can be addressed by significant expansion of the rail networks. In responding to questions about the capacity-constrained situation, the governmental authorities asserted that there is a clear requirement for enhanced "*strategic planning at a national level to* *ensure that the development of the current rail services and the extension of railway lines are studied thoroughly in terms of needs, ridership, demands based on local and global scenarios, plan for capacity handling, as well as type of funding and allocation*".

Third, all stakeholders reported that increasing the punctuality and reliability of rail services remains the major challenges in the industry. These challenges are particularly so for commuter rail services, which suffer considerably from problems such as insufficient train sets available for operation, technical failures on existing train sets, signalling failure, cable theft and vandalism, as well as poor maintenance of train and rail equipments. Rail operators specifically indicated that maintenance of the infrastructure and improvement of operational performance, capacity, and reliability are regarded as the priority issues impacting rail passenger services. Accordingly, all stakeholders reported that there is a need to ensure that ongoing maintenance regimes for track, rolling stock, signalling systems, and other infrastructure are strictly adhered to. There is also a need to inculcate a strong maintenance culture among the rail operators in order to minimise stoppage time and reduce service breakdowns. Continuous improvement in operational safety was also reported as another challenge affecting the rail industry, especially in minimising accidents or service disruptions due to external circumstances such as flash floods and land vehicle collisions.

Fourth, creating a seamless transportation system in Greater Kuala Lumpur and Klang Valley is another key issue facing the rail industry. There is growing interest in integrating the various rail services by having interconnectivity and user-friendly facilities as well as complementing the rail services with other modes of public transport such as buses and taxis. However, the creation of a seamless public transport system is largely constrained by issues of physical and fare integration. At present, constraints that exist on all current rail facilities and services involve the lack of the infrastructure that allows passengers to transfer between rail services and other modes of transport, and the lack of a common ticketing system for rail and other transport modes. Nevertheless, both MOT and DOR believed that an integration of automatic fare collection systems would somehow address these issues. Another option being considered includes the construction of fully integrated multimodal public transport terminals that are capable of transfer between road, rail, and other transport modes.

The final concern raised by the stakeholders revolves around the issues of raising public awareness to enhance railway security and improving public transport's social image. In most cases, the stakeholders are concerned about incidents of anti-social behaviour such as theft and vandalism on railway track component, cables, and infrastructure or facilities, which may cause serious accidents or derailments. They were also keen to introduce further initiatives in order to generate more choice rather than captive riders. Accordingly, several awareness campaigns on public transport usage will be introduced in the future.

Operating as a non-governmental organisation, TRANSIT raised three other critical issues with respect to the challenges and constraints faced by the rail industry. First, it strongly believes that one of the most substantive issues encompassing the whole transportation industry relates to the inconsistent level of national standards, which contributes to poor planning and regulation. While the organisation fully supports the government’s plan for public transport network integration, it expressed continued doubts about the administrative capacity for implementing the plan. TRANSIT stated that the involvement of different federal ministries, departments, and government-linked companies with different roles but overlapping institutional authorities created "*a huge tangle of bureaucratic confusion*", and this results in perpetuation of uncoordinated planning, inadequate legislation, lack of timely investment, and ineffective management and law enforcement.

Closely related to the issue raised above is the question of regional and local planning of the public transportation system. In its studies, TRANSIT has observed that the government's development planning for public transportation services is usually "*an afterthought to development wherein public transit is forced to catch up to development, rather than being integrated into the development at an early stage*". For instance, local and state agency planning is not well coordinated and tends to focus on traffic management for those with cars, making it difficult to implement an integrated public transportation system. This scenario, if left unchecked, could limit the success of any efforts to improve public transportation in Malaysia.

The third issue raised by TRANSIT is that the government seems to treat "*public transportation as a competitive business, rather than a service*". The organisation critically questions the government's decision to establish fixed fares at low rates for long periods of time while allowing numerous operators to enter the industry. It claims that this decision has resulted in the transport operators being unable to meet their expenses with the existing fares and increasing competition and thus tend to sacrifice safety and quality at the expense of the public. Altogether, TRANSIT believes that operator-driven competition does not effectively help the public transport industry.

5.5.5. Future plans to address the specified issues and concerns

Despite variations between individual stakeholders, some common themes in the responses to key strategies to overcome the challenges facing the rail industry can be distinguished. This includes plans to mitigate crowding issues.

First, most stakeholders emphasised the importance of governmental funding and policy changes towards rail transport development. RapidKL asserted that funding is essential in order to increase manning and optimisation of resources. A critical but consistent response across all stakeholders argued that there is an urgent need to establish strategic planning to study the overall rail transportation system in terms of demand, capacity, and ridership. A comprehensive framework is also required to determine both long and short-term plans to overcome rail capacity issues, including crowding. MOT summarised this need by asserting that "*planning and establishing a convenient rail-based transport system is essential to encourage the use of rail-based transport and to ensure that rail-based transport development is in line with the socioeconomic development of the country*". All stakeholders believe that without undertaking strategic planning and extensive investment, rail services may not be able to adequately handle future increases in demand and patronage.

Second, stakeholders were appreciative of the efforts made by the government in enhancing the overall capacity and performance of Malaysia's rail network. In its effort to address issues on capacity constraints, the government has purchased 22 new four-car train sets in 2006 to expand the Kelana Jaya line capacity, while another 13 are scheduled to be delivered in stages in mid 2011. At the time of writing, the four-car train sets are already in operation, with an additional 2.4 million commuters using the service (Performance Management and

Delivery Unit (PEMANDU), 2010). Extra carriages will also be provided to increase commuter rail capacity with an additional 10 sets of Electric Multiple Units (EMUs) being called for international tender. Furthermore, 50 units of the existing EMU variants are currently undergoing a major overhaul. One six-car Electric Train Set (ETS) for commuter service during the morning and evening peak for the Seremban – Sungai Buluh line was also introduced in October 2010 to help reduce congestion during peak hours.

To further increase rail capacity and improve efficiency on the rail network, the Malaysian government has initiated four rail extension plans. Two new projects are under development to extend the Ampang line from the current Sri Petaling terminal station through USJ/Puchong to Putra Heights and to extend the Kelana Jaya line from Kelana Jaya through Subang Jaya to Putra Heights. These projects aim to provide rail access to new townships, to provide one major integrated station, and to reduce the number of cars entering the central business district of Kuala Lumpur. Another two projects involve the construction of electrified double tracking, one between Seremban and Gemas, which will allow the KTM Komuter services to be extended from Seremban to Sungai Gadut, and the other between Ipoh and Padang Besar, which will facilitate intercity passenger and freight services.

At the operational level, both rail operators echoed the extension plans outlined by MOT and DOR. In particular, RapidKL reported the extension plan for Ampang line and the ongoing renovation works to existing stations to provide more space and better service. KTMB stated that plans to gradually increase service intervals from 20 minutes to 10 minutes are under development. It also reported several extension plans to serve new catchments on the outskirt of Greater Kuala Lumpur and Klang Valley.

Third, in addressing the issue of creating a seamless public transportation network, MOT and DOR reported that the government has approved the construction of two integrated transport terminals that will be fully integrated with the LRT, commuter rail, high-speed rail, express bus, and taxi services. The first integrated transport terminal for south-bound traffic at Bandar Tasik Selatan started its operation in January 2011, while a similar infrastructure for east-bound traffic at Gombak has been identified and will be constructed at a later stage. To further facilitate the development of seamless public transport operations, an integrated cashless ticketing system and discounted fares for cashless tickets will also be introduced in stages across all public transport operators in Greater Kuala Lumpur.

Fourth, four stakeholders emphasised the significant role that customers can play in facilitating their rail travel. For example, MOT and DOR stated that customers are encouraged to use a monthly pass or stored value ticket to reduce the queues at ticket counters and auto gates. At the same time, customers are encouraged to plan their journey to avoid unnecessary congestion at platforms and on trains. In its effort to raise public awareness against anti-social behaviour, a nationwide railway safety campaign is in the pipeline to sensitise the public to anti-social behaviour at the station and on the train and to explain how these behaviours may affect them. Public participation in this campaign is strongly sought and encouraged.

Fifth, in essence, the majority of the stakeholders believe that by introducing new railway systems, building extensions to railway lines, procuring new rolling stock, constructing transportation hubs and integrated stations, promoting the widespread use of a common ticketing system, and improving the queuing system at platforms can essentially reduce crowding issues while simultaneously accommodating higher patronage. Some of the more overarching plans to mitigate the challenges facing the rail industry, particularly crowding, reported by KTMB include increasing train availability and frequency, allocating more train coaches during peak hours, implementing several techniques to capture crowd flows, and promoting ongoing safety awareness campaigns. This rail operator also strongly argued that creating a complementary rather than competing environment among all transport operators is essential to address the many issues faced by the rail industry in the country.

Taking a more critical stance, TRANSIT stated that it has consistently recommended that the government should take proactive actions to address the full range of public transportation issues confronting the country. TRANSIT believes that a new National Public Transportation Authority (NPTA), which answers directly to a Parliamentary Committee on Public Transportation, should be created first. It proposes that the ultimate goals of the NPTA would be to create a National Strategy for Public Transportation and to establish a complete National Public Transport Network across the country. Ideally, the NPTA would create national quality standards for public transport and integrate these standards with other national plans. At present, there is neither national vision nor national standards for public transportation in Malaysia. TRANSIT argues that without this vision and standards, public transport will not improve.

Once the role of the NPTA has been clearly established as the national body for the planning, funding, and regulation of public transportation, TRANSIT proposes that Local Public Transport Authorities (LPTAs) should be established next. The LPTAs are proposed to be entrusted with regulatory powers to coordinate funding and planning on a local and regional scale, to oversee the public transport operators, and to retain overall control over the routes and enforce the service quality of public transportation services and routes within their jurisdictional areas.

TRANSIT repeated the need for increased government funding for public transport. Claiming that "*the existing system of competition works against the operation of a high quality public transit service*", it believes "*an open Parliamentary Committee would be able to make the necessary investments to maintain and expand public transportation across the country*" and "*regulated competition would be enhanced under the new system provided*". The NGO added that "*under the regulated competition system, local authorities would be able to run the fare system and would be the best choice to implement the subsidy for operators*".

TRANSIT also reported that "*fares are generally not a consideration for the majority of public transport users who are more interested in being able to get to where they want, easily and without major hassle and without waiting too long*". To this end, the NGO stipulates high quality, reliability, safety, and accessibility as the key criteria for encouraging people to use public transport, rather than mere quantity of service. To offer a service that meets these needs, TRANSIT stated that some general guidelines such as keeping public transit no more than 400 m away from people, providing accurate and timely rail and bus schedules and "next train" or "next bus" information, offering one integrated and unified fare system, and ensuring ongoing maintenance and improvements to public transport infrastructures and services should be followed.

5.6 Discussion

The study reported in this chapter examined the issues associated with rail passenger crowding from the particular perspective of rail authorities, train operating companies, and a non-governmental organisation which engages in public advocacy. Data were gathered from five key stakeholders by questionnaire survey and the themes regarding the stakeholders' current perceptions of rail passenger crowding and other critical issues challenging the Malaysian rail industry were examined. The findings showed that ridership across the four rail lines selected for the study is increasing, with two of the lines exceeding their vehicles' loading characteristics in peak periods.

All stakeholders, though acknowledging the growing problem of passenger crowding, clarified that it was not an issue of highest priority in the current context. Rather, the focus of the priorities was predominantly on three areas: (1) structural reforms in transport coordination and regulation, (2) investment in infrastructure development and maintenance, and (3) enhancement of service quality. As a result of this focus, the stakeholders' efforts and resources are essentially geared toward reforming public transport plans, policy, and regulation; addressing capacity constraints; constructing an accessible infrastructure; developing a seamless transportation network; and improving service punctuality and reliability. All these results are elaborated below.

5.6.1 Ridership growth and passenger loading

The findings suggest that ridership patterns across the four rail lines selected for the study are evolving. In particular, KTM Komuter is experiencing the highest ridership growth since 2000, followed by the Ampang line and the Kelana Jaya line. Available data also demonstrates that passenger crowding is widespread on two of the main rail lines. More specifically, both the Kelana Jaya line and KTM Komuter services exceeded their designated loading capacity by 100% during morning peak hours in 2008. These hard data make a strong case for undertaking an inquiry into the issues of rail passenger crowding within this setting. By implication, they validate our perceptions that there is a significant passenger crowding issue in Kuala Lumpur’s rail services. Additionally, these data further justify the selection of Kuala Lumpur as the relevant location to conduct field research for this thesis.

The findings concerning ridership growth and passenger loading also imply that increases in commuter ridership result in increases in passenger loading. It is possible that these increases could, in part, be attributed to a growing urban population and the continued suburbanisation process of the Greater Kuala Lumpur and Klang Valley area (Koegler, 2010). These patterns of development, if left unchecked, would lead to the further growth of mobility, higher public transport patronage, and worsening congestion. In light of this observation, rail operators and key authorities are urged to pursue a comprehensive strategy that promotes efficient transport services and tackles the consequences of additional train patronage. Such a strategy might include loading policy formulations and demand management programmes (House of Commons Committee of Public Accounts, 2010). These propositions are discussed as policy implications in Section 8.7 of Chapter 8.

5.6.2 Benchmarking of service quality across different rail services

The present study reveals that the Malaysian rail industry has few to no formal benchmarking strategies for best practices and performance evaluation of its rail services. Owing to this approach, service quality has been rated differently by the stakeholders. Safety, security, travel comfort, and communication provision were generally rated as moderately good, whereas relatively mixed ratings for punctuality and reliability were reported. Having mixed responses from the different stakeholders to this query indicates that it is possible that the stakeholders hold different perceptions and expectations about service quality attributes and thus evaluate their organisation differently. This perceptive difference need to be addressed so that performance can be more uniformly measured across all rail services. Arguably, a systematic, integrative benchmarking approach becomes relevant to evaluate the performance and efficiency improvements achieved by the rail systems.

A reasonable approach to address this issue could be to establish some benchmarking system to put the rail industries in a comparative perspective. For a start, the Community of Metros (CoMET) and Nova metro benchmarking programmes (Anderson, 2006), which include 24 metro railways from around the world, could be used. In general, the CoMET and Nova processes use 32 key performance indicators to measure the performance of these metro services through six categories, including service quality, reliability, efficiency, asset utilisation, financial performance, and safety. It would be highly desirable that Malaysia adopt methods at least broadly coherent with those envisaged by these two benchmarking frameworks, as such programmes have identified best practices in operations and management, offered insights for policy development, and facilitated information exchange and dialogue across the stakeholder groups of these metro systems (Anderson, 2006). Adding this benchmarking approach to the rail operators' business process and strategic plan would set this initiative in motion.

5.6.3 Priority issues and potential recommendations for interventions and programmes

In the current context, passenger crowding tends to be viewed as a relatively small operational concern. Given the wide variety of issues that the rail industry faces, ranging from policy and governance problems to funding and operational considerations, it is understandable that priority is not assigned to addressing passenger crowding. The more pressing issues that are facing the rail industry, for instance, are a lack of long-term investment strategies and planning, inadequate train capacity, poor service reliability, and a lack of integration between transport modes and providers. Consequently, future plans and intervention strategies tend to focus on infrastructure development, network expansion, capacity enhancement, service improvement, and industry restructuring of rail services. Nonetheless, there is a view within the industry that improved capacity and service reliability could somewhat reduce passenger crowding problem.

One clear implication arising from the above findings is that there is a need for a cost-effective, if not cheap, measure for addressing issues associated with passenger crowding. With an understanding of the financial and management constraints affecting the industry, an integrated approach of cost-effective strategies tailored to the particular circumstances of each rail system seems to offer the best prospect for managing passenger crowding. This is consistent with the observations of Cox et al. (2006; 2003) that psychologically targeted interventions are both cost-effective ways of managing the growing demand on the rail services and contribute to improvement in service quality. The findings of the present study show that the potential use of psychological interventions as crowding reduction initiatives remains largely untapped, with only a few stakeholders considering raising customers' travel awareness and promoting change in travel behaviour as future plans to tackle a variety of transportation issues. This situation, therefore, offers an ideal opportunity to promote psychological or non-engineering interventions that can effectively mitigate the potential effects of rail passenger crowding. Several possible ways of implementing such an intervention are explicitly discussed as practical implications in Section 8.6 of Chapter 8.

5.7 Chapter summary and conclusions

This chapter has presented the main results of a survey of five key stakeholders. The findings from the written responses have been discussed in the context of five underlying themes. Taken together, the findings show that the relevant research aims were achieved in that the background and context within which this thesis work took place have been set and the issues faced by the rail industry in Malaysia, including future initiatives being developed to address these issues, have been identified.

In addition, the present study has generally confirmed that passenger crowding is becoming an issue in Malaysia’s rail industry, particularly at peak times. It has also provided justification for choosing rail systems in Kuala Lumpur as the location for the field research as well as laid the foundation for subsequent studies in the thesis. Having obtained substantial input from rail operators, governmental authorities, and non-governmental organisations, it is imperative that the instrument for measuring the experience of rail passenger crowding is established, and that the views of the most important stakeholder group, the commuters or passengers, are actively sought. The following chapters present the scale development and the psychometric characteristics of the rail passenger crowding instrument used in this thesis and the empirical results obtained from the passenger survey; both of which provide answers to each of the five research questions outlined in Chapter 3.

CHAPTER 6 – MEASURING RAIL PASSENGER CROWDING: SCALE DEVELOPMENT AND PSYCHOMETRIC PROPERTIES

6.1 Chapter overview

This chapter describes the development of an instrument that captures the dimensionality and measurement of rail passenger crowding experience used in Phase Two. The proposed instrument is a 20-item self-rating questionnaire consisting of three sub-scales designed to assess subjective crowding experiences among rail users. The chapter first provides an introduction to the measurement issue concerning this construct in the literature. It then proceeds with the description of the current investigation and the method used in the scale development for this research work. Next, the results of the psychometric evaluation of the proposed instrument are presented. Findings from the exploratory and confirmatory factor analyses supported the hypothesised three-factor structure of the measurement model (evaluation of the psychosocial aspects of the crowded situation, evaluation of the ambient environment of the crowded situation, and affective reactions to the crowded situation). Overall, the results reveal satisfactory psychometric properties for the proposed instrument and support its use as an assessment tool for measuring crowding experience in a transportation setting. The chapter ends with some interpretations of the results in light of the current research questions and conceptual approach.

6.2 Introduction

The discussions in Chapters 2 and 4 have highlighted the lack of agreement on the definition and measurement of crowding in the rail literature. It appears that crowding is defined more often as a quantitative and objectively verifiable experience based on measurements such as passenger density or train capacity (for example, Dodgson et al., 2002; RSSB, 2004; Lam, Cheung, & Lam, 1999; Lam, Cheung, & Poon, 1999). In addition, only a few studies measured subjective crowding – mostly via self-rating of crowding experiences in which participants were asked to rate levels of density inside the trains (for example, Evans & Wener, 2007; Wener et al., 2006; Wener & Evans, 2004; Buckley & O'Regan, 2004; Wener et al., 2003; Singer et al., 1978; Lundberg, 1976). The problem of using density and crowding as interchangeable terms and the lack of a precise definition of rail passenger crowding thus predictably leads to difficulties in its measurement.

To date, a standardised instrument has yet to be developed that assesses the different psychological components of crowding. At present, our knowledge is derived from a relatively small number of studies which tend to be conducted in the residential or retail setting. For example, the scale used in Kaya and Weber's study (2003) is made up of six items with a seven-point Likert scale measuring crowding experience in a residence hall environment and ten items with a semantic differential response scale that assesses the perception of hall room. Meanwhile, the scales used in studies by Evans et al. (2000) and Fuller et al. (1993) consist of items that ask about household crowding in terms of the level of crowding experienced and restricted movement. Crowding scales developed in retail studies such as those by Harrell, Hutt, and Anderson (1980) and Machleit, Kellaris, and Eroglu (1994) also more or less consist of similar dimensions of confined or closed-in feelings and restricted movement.

Only a few attempts have been made to distinguish the measurement of physical density from that of the subjective evaluation of crowding. For instance, Kalb and Keating (1981), who constructed a scale consisting of 28 items with a ten-point bipolar semantic differential response scale that measures how crowded people feel, how crowded people rate a setting, and how people rate the crowding ambience, found that these three components can be attributed to individuals' experience of crowding. In particular, they discovered that self-ratings of crowding experienced and description ratings of crowdedness are conceptually distinct, since the feeling of crowdedness component is loaded with perceived density, constraint, distraction, and stress. On the other hand, the description rating component is loaded only with perceived density and general negative affects. The feeling of crowdedness was also found to be more sensitive to changes in physical density than the description rating of crowdedness. Relatively similar dimensions are also identified to be distinctive in Mohd Mahudin's (2003) study. According to this study, crowding can be described and measured in terms of eight components: physical, social, personal, psychological, crowd characteristics, crowd dynamics, crowd behaviour, and location. Four of the components, i.e. physical, social, personal, and psychological, relate to the feelings of crowdedness, whereas crowd characteristics, crowd dynamics, crowd behaviour, and location describe where crowding takes place.

While these scales have previously been identified as promising for assessing respondents' crowding experience and appeared to correspond with current definitions of crowding experience, they had neither been verified nor tested for use in the rail passenger context. With the exception of scales by Machleit et al. (1994), Harrell et al.

(1980), and Kalb and Keating (1981), a thorough analysis of the psychometric properties of the scales is neither conducted nor reported. Furthermore, measuring passengers' crowding experiences based solely on density remains limited, particularly when examining individual, subjective perceptions of crowdedness, and fails to capture many of the outcomes that might occur as a result of crowding (Cox et al., 2006). In essence, the scales developed so far are relatively inadequate in tapping the overall dimensions of crowding experience. Consequently, there is a need to develop a valid and reliable scale that can capture the various psychological components of crowding which has practical relevance for use in the transport context, particularly rail passenger services.

In the realm of rail studies, several researchers have differentiated between passenger density and perceived crowdedness or crowding. For example, in their review article, Cox et al. (2006) refer crowding as "a psychological phenomenon that is created from an interplay of cognitive, social, and environmental factors" (p. 248). Findings of Evans and Wener's (2007) study, meanwhile, suggest that the immediate, close presence of other passengers in a train car is more salient for the experience of crowding than the overall train density. Insights from these studies together with those from Kalb and Keating (1981) therefore suggest that some distinctions can be made between the crowding experience, the essentially psychosocial characteristics of the crowded situation, and those of its ambient environment. It is argued that all three components of crowding, together with passenger density, may have roles to play in determining both their direct and spillover effects on individuals. Furthermore, in doing so there is interplay between the different components. For example, it has been shown that high-density situations may affect both perceived crowding (Cox et al., 2006; 2003) and induce affective feelings of crowdedness

(Bell et al., 2001; Baum & Paulus, 1987). This is the conceptual approach used in this thesis to develop the proposed instrument.

6.3 The current investigation

The first research question of this thesis sought to develop and test an instrument that captures the dimensionality of crowding experience. The proposed new instrument was designed to tap three different psychological components or latent factors of crowding, hypothesised to be: (1) affective reactions to the crowded situation or affective experience of crowding, (2) evaluation of the psychosocial aspects of the crowded situation, and (3) evaluation of the ambient environment of the crowded situation.

The development of the instrument took place in two progressive stages. In the first stage, the draft items were evaluated for content validity through a pilot study on a sample of commuters who had commuting characteristics similar to those of the study population. The instrument was revised based on the results of the reliability analyses and content validity ratios conducted. In the second stage (the main study), the psychometric properties and internal consistency of the instrument were investigated via a passenger survey. The following sections present further details of the instrument development process.

6.4 Method

6.4.1 Initial item development and pilot study

The initial list of possible items for measuring the different psychological components of crowding was generated by surveying existing scales and reviewing the literature. A single scale which comprised of nine items was then developed and piloted on 25 individuals who commuted to work regularly and frequently using the LRT or commuter rail services. The respondents were asked to rate their agreement with statements such as "The train I commute on is usually crowded" and "There is not enough space on the train for commuters", using a six-point Likert scale ranging from 1 (*Strongly disagree*) to 6 (*Strongly agree*), with higher total scores indicating a greater experience of crowding.

Besides filling in the questionnaire, the respondents were asked to identify the items that they viewed as covering the essential aspects of the experience of crowding as a construct. Lawshe (1975) developed this technique as a method to gauge agreement among raters regarding how essential a particular item is to content validity. In the present study, this task was conducted to explore how each item is judged to be reflective of or theoretically linked to the targeted construct. For each item, the respondents indicated one of three choices: "*Essential*", "*Useful*", and "*Not necessary*". The content validity ratio (CVR) for each item was then calculated using the following formula (Lawshe, 1975):

$$\text{CVR} = \frac{(\text{Number of respondents indicating the item "essential"}) - (N/2)}{N/2}$$

The CVR value ranges from -1 to +1, with values closer to +1 indicating that the respondents agree that the item is essential to content validity. Greater levels of content validity exist as larger numbers of respondents agree that a particular item is essential (Joseph & Dai, 2009).

In addition to the protocols described above, the respondents completed a supplemental section that asked them to comment on the wording and ordering of the items as well as on the overall questionnaire format and layout.

6.4.2 Item refinement

Only items that exceed the minimum recommended level of Cronbach's coefficient alpha of .70 (Nunnally & Bernstein, 1994) and have a CVR value higher than .49 were retained. According to Lawshe's (1975) formula, a minimum CVR value of .49 is required for 15 panel members.

Two specific points of interest were highlighted in the qualitative comments from the respondents. These include the importance of categorising the items according to the hypothesised dimensions and the need for a better and clearer response scale format for all items. In light of this evidence, three decisions were made when refining the proposed instrument. First, it was decided to add some items and group them according to the three constructs being tapped, namely affective reactions to the crowded situation and evaluation of the psychosocial aspects of the crowded situation and of its ambient environment. Second, the response scale format was changed from the strongly disagree-strongly agree to a construct-specific response scale format. The latter format, which involves phrasing the response in terms of the construct being measured, was chosen because it has been proven to have greater accuracy, reliability, and stability compared to disagree-agree format (Saris, Revilla, Krosnick, & Shaeffer, 2010; Ping, 2005). Finally, the three groups of crowding items were treated as separate scales in their own right. The basis for this decision stems from Kalb and Keating's (1981) and Mohd Mahudin's (2003) studies discussed earlier in Section 6.2.

The refined instrument used in the main study therefore consisted of three separate scales with a five-point construct-specific response scale format. The first subscale was named "evaluation of the psychosocial aspects" with seven items, while the second subscale consisted of nine items named "affective reactions to the crowded situation" subscale. Meanwhile, the third subscale comprised four crowding atmosphere items and was called "evaluation of the ambient environment". For each subscale, items were summed, with higher scores indicating a more negative experience of crowding.

6.4.3 Main study

The revised instrument was tested on a sample of 525 commuters in the passenger survey conducted. It was hypothesised that the experience of crowding is constructed of three different psychological components or latent factors: (1) affective reactions to the crowded situation or affective experience of crowding, (2) evaluation of the psychosocial aspects of the crowded situation, and (3) evaluation of the ambient environment of the crowded situation; all measured by 20 indicator variables (*Hypothesis H1a*). It was also hypothesised that the three latent factors are intercorrelated, that each item loads on one and only one factor, and that the measurement errors are not correlated with one another; that is, there are no common response tendencies influencing the measures in a similar way (*Hypothesis H1b*).

The hypothesised model of the crowding measures is presented in Figure 6.1, where circles represent latent variables and rectangles represent measured variables. Absence of a line connecting variables indicates no hypothesised direct effect. A three-factor model of the experience of crowding is proposed. The first subscale is represented by items characterising the respondents' evaluation of the psychosocial aspects of the crowded situation such as "dense", "disorderly", "confining", "chaotic", "cluttered", "disturbing", and "unpleasant". These items serve as indicators of the first hypothesised component. Items which are designed to be strongly associated with behavioural constraint, interference, and stress serve as indicators of the affective reactions to the crowded situation component (Subscale 2). The evaluation of the ambient environment of the crowded situation comprises items that share similar properties in describing the physical-environmental dimensions of the setting (Subscale 3). Items that relate to noise, heat, ventilation, and air quality serve as indicators of this component.

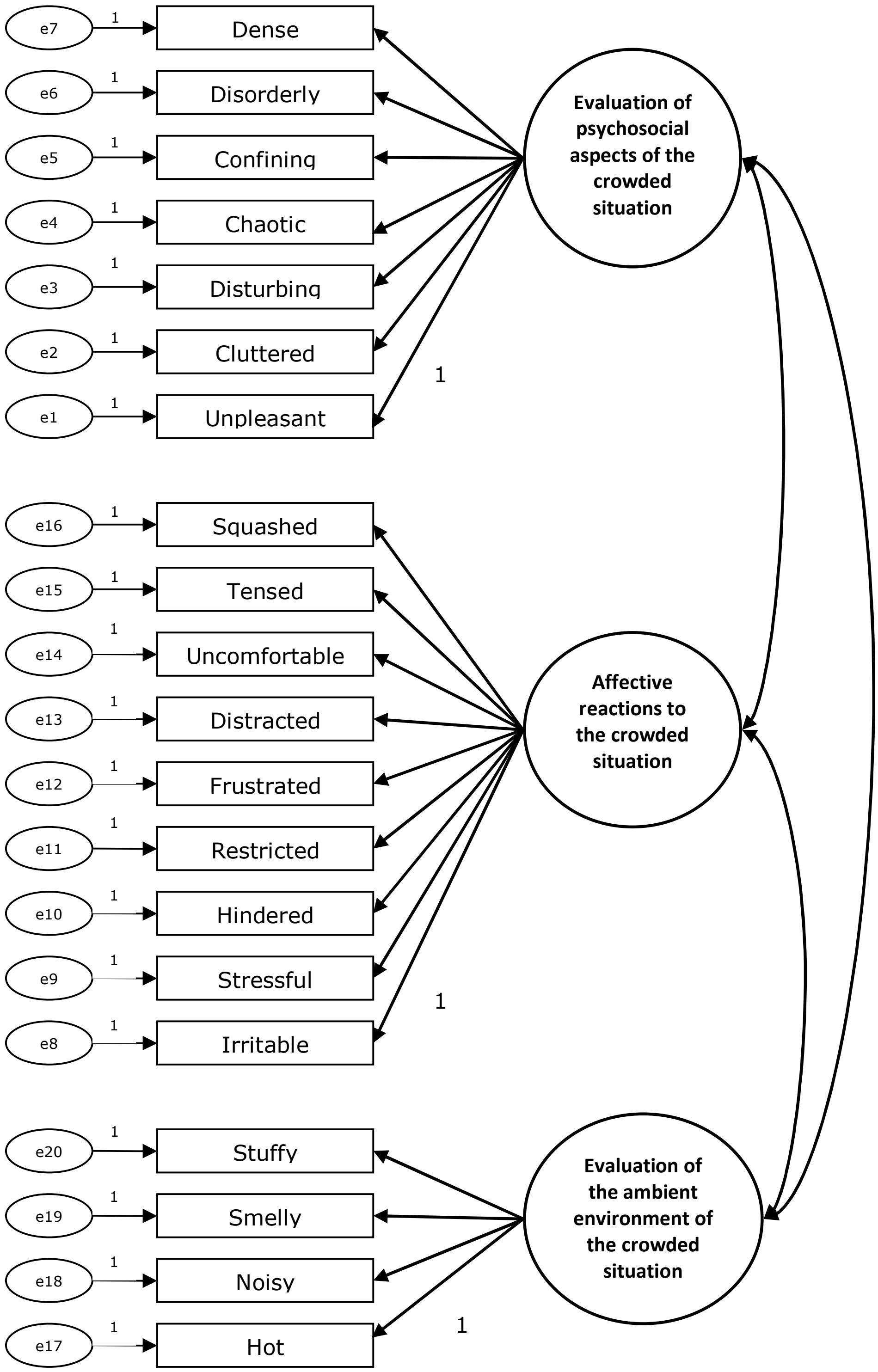

Figure 6.1. The hypothesised model of crowding experience.

6.4.4 Statistical analysis

In order to test the preceding hypotheses, exploratory factor analysis, reliability analysis, and convergent and discriminant validity were used to address the reliability and validity issues. Confirmatory factor analysis was then carried out via AMOS 16.0 to determine the degree of model fit and the adequacy of the factor loadings.

6.5 Results

6.5.1 Exploratory factor analysis

Using Pearson correlations, all items significantly correlated at least .28 with the rated passenger density item, indicating positive correlations between these variables. All items are also significantly correlated at least .314 with one other item, suggesting reasonable factorability. Table 6.1 presents the descriptive statistics for the items.

Table 6.1.

Descriptive statistics for items of crowding subscales (N = 525)

Items	**M**	**SD**	**Skewness**		**Kurtosis**	
			Statistic	S.E.	Statistic	S.E.
Dense	3.16	1.095	-.106	.107	-.704	.213
Disorderly	2.83	1.059	.169	.107	-.521	.213
Confining	2.89	1.075	.062	.107	-.645	.213
Chaotic	2.69	1.172	.254	.107	-.778	.213
Disturbing	2.76	1.187	.198	.107	-.792	.213
Cluttered	2.84	1.152	.139	.107	-.808	.213
Unpleasant	2.98	1.133	.112	.107	-.760	.213
Squashed	2.88	1.175	.085	.107	-.810	.213
Tensed	2.82	1.173	.181	.107	-.730	.213
Uncomfortable	3.01	1.182	.075	.107	-.872	.213
Distracted	2.77	1.139	.107	.107	-.636	.213
Frustrated	2.60	1.254	.335	.107	-.914	.213
Restricted	2.67	1.144	.301	.107	-.642	.213
Hindered	2.69	1.138	.212	.107	-.668	.213
Stressful	2.66	1.245	.268	.107	-.946	.213
Irritable	2.72	1.230	.223	.107	-.914	.213
Stuffy	2.73	1.150	.191	.107	-.723	.213
Smelly	2.56	1.165	.428	.107	-.586	.213
Noisy	2.45	1.091	.463	.107	-.329	.213
Hot	2.48	1.162	.483	.107	-.553	.213

Exploratory factor analyses were conducted using three separate principal axis factoring (PAF) extraction methods with varimax rotation to assess the dimensionality of these subscales. Separate analyses were employed because, as previously stated in Section 6.2, the literature suggests that the experience of crowding is made up of three distinctive theoretical factors. A summary of the PAF results is presented in Table 6.2.

Table 6.2.

Factor loadings based on three principal axis factoring analyses for 20 items of the crowding subscales (N = 525)

Measure	Items	Factor loading[a]	Factor loading[a]	Factor loading[a]	Cronbach's alpha	Total variance explained
Subscale 1	Unpleasant	.878			.940	73.73%
Evaluation of	Disturbing	.877				
psychosocial	Cluttered	.852				
aspects of the	Chaotic	.834				
crowded	Dense	.823				
situation	Disorderly	.817				
	Confining	.746				
Subscale 2	Irritable		.903		.966	78.92%
Affective	Frustrated		.902			
reactions to the	Tensed		.895			
crowded	Distracted		.884			
situation	Stressful		.874			
	Hindered		.864			
	Restricted		.860			
	Uncomfortable		.855			
	Squashed		.822			
Subscale 3	Hot			.828	.870	71.93%
Evaluation of the	Smelly			.816		
ambient	Stuffy			.794		
environment of	Noisy			.726		
the crowded						
situation						

a. Factor loadings presented are the unrotated factor matrix because only one factor was extracted for each subscale and the solutions cannot be rotated.

b. Factor loadings < .40 are suppressed.

The results show that all items correlate at least .50 with one other item in their hypothesised latent factors. Each PAF suggests that one factor that could be extracted is related to its hypothesised component. Overall, the loadings for each subscale are consistent and none of the items are loaded highly on more than one factor. The Kaiser-Meyer-

Olkin index of sampling adequacy is .932, .961, and .819 respectively, while Bartlett's measures are all significant, both supporting the factorability of the correlation matrices. Furthermore, 73.73% of total variance was accounted for by the evaluation of the psychosocial aspects subscale; 78.92% of total variance was accounted for by the affective reactions to the crowded situation subscale; and 71.93% of total variance was accounted for by the evaluation of the ambient environment subscale.

6.5.2 Internal reliability

Internal reliability of the instrument was determined by examining the Cronbach's alpha coefficients. The value for each subscale exceeds the .70 level recommended by Nunnally and Bernstein (1994): respondents' evaluation of the psychosocial aspects of the crowded situation ($\alpha = .94$) and of its ambient environment ($\alpha = .87$), and their affective reactions to the crowded situation ($\alpha = .97$); indicating fairly strong scale reliability and internal consistency. No substantial increases in alpha for any of the subscales could have been achieved by eliminating more items.

6.5.3 Confirmatory factor analysis

The hypothesised three-factor model was examined to ensure that all variables in the model accurately corresponded to their intended latent factors. This generally involves assessing the reliability and validity of the constructs and indicator items. Reliability refers to the consistency of measurement whereas validity refers to the extent to which an instrument measures what it is supposed to measure (Hatcher, 1994). Confirmatory factor analysis was used to assess the indicator reliability and construct validity as well as the convergent and discriminant validity of the measures and to test whether the experience of crowding can be explained by the three latent factors proposed. SEM analyses were then performed using data from all respondents to determine model fit. Since AMOS 16.0 can only compute standardised regression weights, computations for construct and discriminant validity such as composite reliability and average variance extracted were calculated separately in a spreadsheet using Hatcher's (1994) equations.

6.5.3.1 Validity and reliability of the hypothesised model

First, all factor loadings were significant ($p < .001$), demonstrating that the items for each latent variable reflect a single underlying construct. Second, an analysis of indicator reliability was performed on all items. The reliability of an indicator or observed variable is defined as the square of the correlation between a latent factor and that indicator. This value represents the percentage of variation in the indicator that is explained by the factor or R^2 (Hatcher, 1994). According to Fornell and Larcker (1981), indicator reliability should capture 50% of the variation in the indicator (that is, should be greater than .50). A summary of the results obtained in the present study is depicted in Table 6.3.

Table 6.3.

Psychometric properties of the hypothesised model (N = 525)

Constructs and indicators	Std factor loading	Critical ratio and P		Error variance[b]	Reliability			
		CR	P		Indicator reliability[c]	Composite reliability	Cronbach's alpha α	Average extracted variance
Evaluation of the psychosocial aspects of the crowded situation						.940	.940	.691
Unpleasant	.872			.240	.760			
Cluttered	.856	26.879	***	.267	.733			
Disturbing	.899	29.753	***	.192	.808			
Chaotic	.848	26.425	***	.281	.719			
Confining	.726	20.241	***	.473	.527			
Disorderly	.802	23.811	***	.357	.643			
Dense	.805	24.001	***	.352	.648			
Affective reactions to the crowded situation						.967	.966	.764
Irritable	.903			.185	.815			
Stressful	.876	30.851	***	.233	.767			
Hindered	.868	30.170	***	.247	.753			
Restricted	.857	29.307	***	.266	.734			
Frustrated	.899	33.008	***	.192	.808			
Distracted	.881	31.343	***	.224	.776			
Uncomfortable	.857	29.286	***	.266	.734			
Tensed	.894	32.453	***	.201	.799			
Squashed	.828	27.192	***	.314	.686			
Evaluation of the ambient environment						.866	.870	.619
Hot	.820			.328	.672			
Noisy	.685	16.888	***	.531	.469			
Smelly	.775	19.887	***	.399	.601			
Stuffy	.857	22.820	***	.266	.734			

[a.] The first item for each subscale was set to 1.00. All factor loadings were significant at $p < .001$.

[b.] Error variance was calculated as 1 minus the indicator reliability.

[c.] Indicator reliability scores were calculated as the square of the standardised factor loading.

From Table 6.3, we can see that the indicator reliabilities for affective reactions to the crowded situation items were all above .686, while the indicator reliabilities for the evaluation of the psychosocial aspects subscale were all above the recommended range of .50. Regarding the range of indicator reliabilities for the evaluation of the ambient environment subscale, three items have relatively high reliabilities (.60 and above); however, one item (*Noisy*) has slightly low reliability (.469). Although the latter's result suggests that the validity of the item may be questionable, it was decided to retain this item in the model because it represented a key descriptor in this subscale. Furthermore, removing this item from the scale decreased the Cronbach's alpha for the scale to .854 from .870.

Third, a composite reliability index was calculated to assess construct validity using the following equation (Hatcher, 1994):

$$\text{Composite reliability} = \Sigma\ [L_i]^2 \ /\ [\Sigma\ L_i]^2 + \Sigma\ \text{Var}\ (E_i)$$

Where:

L_i = the standardised factor loadings for that factor
Var (E_i) = the error variance associated with the individual indicator variables

In general, composite reliability should be above .70, with .60 considered minimally acceptable (Hatcher, 1994; Bagozzi & Yi, 1988). As shown in Table 6.3, all subscales had composite reliability coefficients exceeding .87, indicating that the reliabilities of all subscales were acceptable.

Fourth, variance extracted estimates were computed using the following equation (Hatcher, 1994):

$$\text{Variance extracted} = \Sigma L_i^2 / \Sigma L_i^2 + \Sigma \text{Var}(E_i)$$

Where:

L_i = the standardised factor loadings for that factor
$\text{Var}(E_i)$ = the error variance associated with the individual indicator variables

These estimates assess the amount of variance that is explained by an underlying factor in relation to the amount of variance due to measurement error (Hatcher, 1994). Values of .50 or larger are considered desirable because estimates lower than .50 indicate that variance due to measurement error is greater than the variance captured by the latent factor (Hatcher, 1994; Fornell & Larcker, 1981). As seen in Table 6.3, the variance extracted estimates all exceed the .50 criteria, further suggesting the reliability and validity of all latent factors.

Fifth, convergent validity was determined from the hypothesised model by examining the statistical significance of the factor loadings of the indicators of each latent factor. Convergent validity is present when different instruments are used to measure the same construct, and scores from these different instruments are strongly correlated (Hatcher, 1994). For a probability of .05, the critical ratio should be higher than 1.96 and the standardised factor loadings of each indicator in the latent variable on which it saturates should be higher than .40 (Hair, Black, Babin, Anderson, & Tatham, 2006). Furthermore, Anderson and Gerbing (1988) suggest that the parameter estimates should be high in value and t-values should be statistically significant, indicating that all indicators are effectively measuring the same construct. As shown in Table 6.3, all standardised loadings and critical ratios exceed the recommended minimum levels of .40 and 1.96 respectively. The measures in the resulting model indicate that convergent validity was obtained, with each measure being significantly related to its underlying factor.

Sixth, the discriminant validity (the degree to which two conceptually similar constructs are distinct) of the crowding subscales was determined in two ways. First, following suggestions by Kline (2011), the correlations between the constructs were examined. If the correlations are below .85, thus not highly correlated, then it can be assumed that they represent different constructs (Kline, 2011). As shown in Table 6.4, all correlations between the latent factors are below .85, providing evidence of discriminant validity.

Table 6.4.

Discriminant validity among the latent factors

	Latent factors	**1**	**2**	**3**
1	Evaluation of the psychosocial aspects of the crowded situation	**.691**	*.714*	*.493*
2	Affective reactions to the crowded situation	.845	**.764**	*.604*
3	Evaluation of the ambient environment	.702	.777	**.619**

[a.] The diagonal entries (**in bold**) represent the average amount of extracted variance for each construct.

[b.] The Pearson correlations between constructs are shown in the lower triangle.

[c.] The variances shared between constructs are shown in italics in the upper triangle (calculated as the squares of correlations between constructs).

[d.] All correlations are significant at the $p < .001$ level.

Another way to measure discriminant validity is by comparing the variance extracted estimates for the factors with the squared correlations between the factors (Hatcher, 1994). Discriminant validity is demonstrated if all variance extracted estimates are greater than the squared correlation (Hatcher, 1994). As can be seen in Table 6.4, the variance extracted estimate was .691 for the evaluation of the psychosocial aspects subscale and .619 for the evaluation of the ambient environment subscale. As these variance extracted estimates are greater than the square of the factor correlation (that is, .493), the test supports the discriminant validity of these two factors. Examination of the other variance extracted estimates and squared correlation coefficients also generally support the discriminant validity of the components within the model, with only a slight exception between the evaluation of the psychosocial aspects subscale and affective reactions to the crowded situation.

In view of these data, findings from the exploratory and confirmatory factor analyses supported the hypothesised three-factor structure of the hypothesised model (*Hypothesis 1a*). The results of the indicator reliabilities, composite reliabilities, variance extracted estimates, and convergent and discriminant validities also supported *Hypothesis 1b*. All subscales demonstrated excellent internal consistency and construct validity as well as good convergent and discriminant validity of both the indicator items and their corresponding latent factors.

6.5.3.2 Model estimation: Goodness-of-fit indices

Following Hair et al.'s (2006) recommendations, the adequacy of the hypothesised model was estimated using four categories of fit indices. As mentioned in Section 4.3.6 of Chapter 4, Maximum Likelihood (ML) estimation was employed to estimate all models.

The first category is the absolute fit indices that measure the degree of overall discrepancy between the implied and observed covariance matrices and do not use an alternative model as a base for comparison (Byrne, 2009; Hooper, Coughlan, & Mullen, 2008). Two examples of such fit indices include the chi-square statistic (along with its degrees of freedom and significance level) and the standardised root mean residual (SRMR). However, the chi-square statistic is known to be highly sensitive to both sample size and the assumption of multivariate normality (Byrne, 2009; Hooper et al., 2008) and this sensitivity may overstate the lack of fit of a model and increase the likelihood of a Type II error (Bollen, 1989). Therefore, chi-square is not considered to be the absolute standard by which goodness-of-fit of a model is judged (Bollen, 1989). For this reason, the model was also assessed using other indices that reflect the different facets of model fit.

The SRMR is a measure of the average size of residuals between the fitted and sample correlation matrices (Byrne, 2009). Values for the SRMR range from 0 to 1, and when the model fit is perfect, SRMR equals zero. Byrne (2009) suggests that well-fitting models obtain values less than .05; however, values as high as .08 are deemed acceptable (Hu & Bentler, 1999).

The second category, the incremental fit indices, assesses how well a specified model fits relative to an alternative baseline model. The comparative fit index (CFI) is reported under this category. This index, which is one of the measures least affected by sample size, adjusts the chi-square for the degrees of freedom (Hooper et al., 2008; Fan, Thompson, & Wang, 1999). Values for this statistic range between 0 and 1, with values closer to 1 indicating good fit (Byrne, 2009). A cut-off criterion of .90 or larger was initially recommended (Bollen, 1989; Bentler & Bonett, 1980); however, recent studies have shown that a value greater than .95 is recognised as an indicator of good model fit (Byrne, 2009; Hu & Bentler, 1999).

The third category involved parsimonious fit indices that measure the trade-off between the model fit and the degrees of freedom while assuming that the absolute fit may be improved with a sacrifice of the degrees of freedom (Byrne, 2009). The parsimonious normed fit index (PNFI: James, Mulaik, & Brett, 1982) is used in this study. This index is a conservative measure of fit because it takes into account the number of degrees of freedom used to achieve a level of fit. Unlike the other fit indices, no agreed threshold levels have been recommended for these indices to indicate levels of acceptable parsimonious fit (Hooper et al., 2008). However, Marcoulides and Hershberger (1997) suggest that a threshold value of .60 with higher values indicates a better fit.

The last category of fit index used to interpret the proposed model is the noncentrality-based indices, where the noncentrality parameters are calculated by subtracting the degree of freedom of the model from the chi-square (χ^2 - df). The root mean square error of approximation (RMSEA) that tests whether a model is a close fit to the data rather than a perfect fit is reported under this category. The RMSEA has been considered as one of the most informative fit indices due to its sensitivity to the number of estimated parameters in the model (Byrne, 2009; Schumacker & Lomax, 2004; Diamantopoulos & Siguaw, 2000; Browne & Cudeck, 1992). Although a cut-off value close to .06 (Hu & Bentler, 1999) or a stringent upper limit of .07 (Steiger, 2007) seems to be the general consensus at present (Hooper et al., 2008), several authorities such as Schumacker and Lomax (2004), Byrne (2009), and Browne and Cudeck (1992) have suggested that RMSEA values of less than .05 indicate a good model fit, whereas values which are less than or equal to .08 indicate an adequate fit.

Altogether, the five fit indices used in this study (chi-square statistic, SRMR, CFI, PNFI, and RMSEA) were selected over other indices because they have been found to be the most insensitive to model misspecification and parameter estimates (Hooper et al., 2008).

Table 6.5 and Figure 6.2 present the results. Although the model yielded a significant chi-square, χ^2 (n = 525, df = 167) = 651.051, p = .001, a result that is not uncommon with large sample sizes (Byrne, 2009; Hooper et al., 2008), the other indices meet the criteria for adequacy of fit (SRMR = .034; CFI = .955; PNFI = .826; and RMSEA = .074). These results thus support and strengthen the research's hypotheses on the adequacy of the crowding measures developed in the present study.

Table 6.5.

Fit indices for the hypothesised three-factor model (N = 525)

Fit index	Recommended criteria	Value
Chi-square statistic (χ^2)	• Chi-square value should not be significant if there is a good model fit (Byrne, 2009).	651.051
Degrees of freedom (df)		167
P		.001
SRMR	• Good model fit: SRMR less than .05 (Byrne, 2009). • Adequate model fit: SRMR less than or equal to .08 (Hu & Bentler, 1999).	.034
CFI	• Good model fit: CFI equal or above .95 (Byrne, 2009; Hu & Bentler, 1999). • Adequate model fit: CFI value between .90 and .95 (Bentler & Bonett, 1980; Bollen, 1989).	.955
PNFI	• Recommended threshold of .60 (Marcoulides & Hershberger, 1997).	.826
RMSEA	• Good model fit: RMSEA less than or equal to .05 (Byrne, 2009). • Adequate model fit: RMSEA less than or equal to .08 (Schumacker & Lomax, 2004; Byrne, 2009; Browne & Cudeck, 1992).	.074

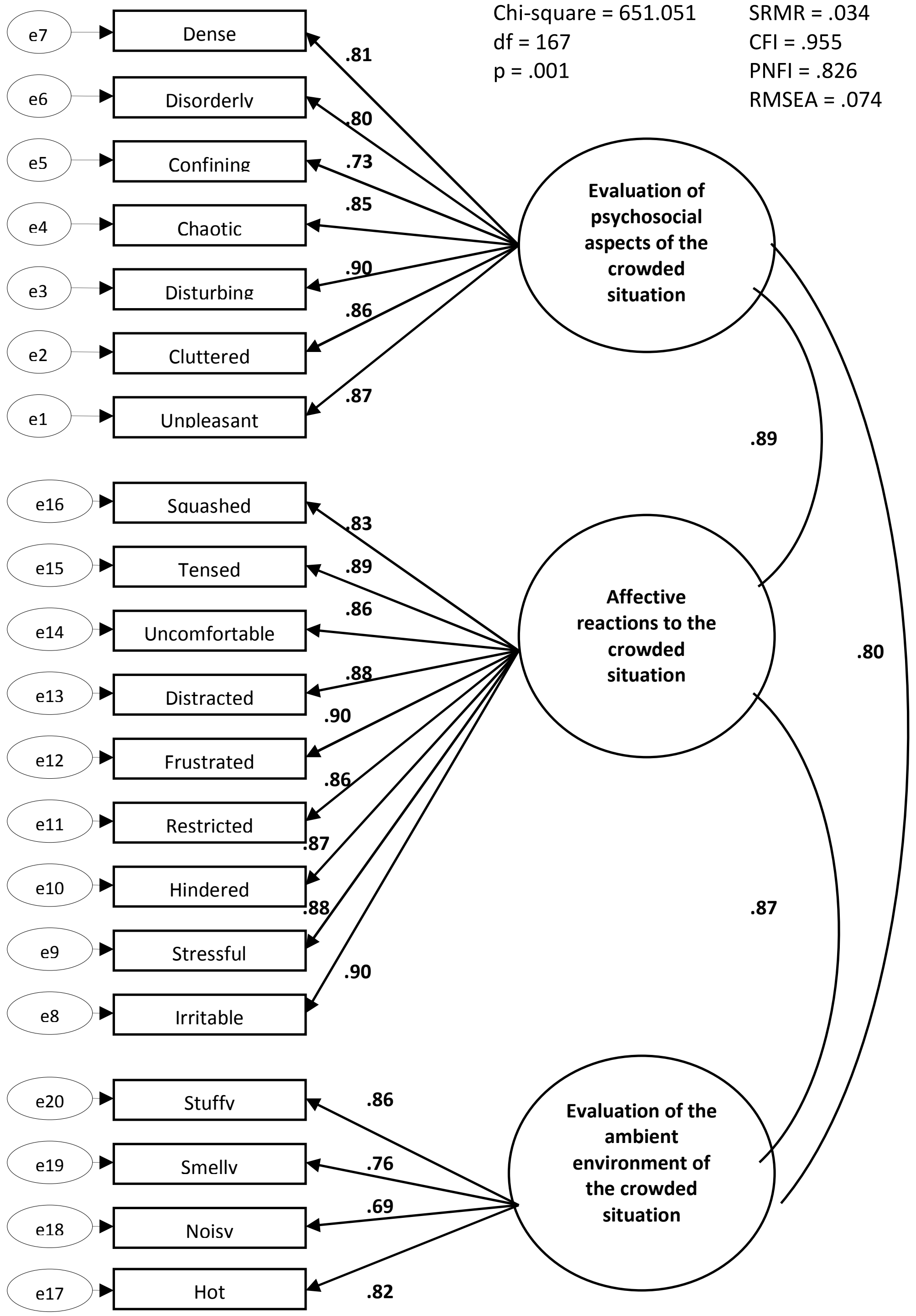

Figure 6.2. Results for the hypothesised model of rail passenger crowding experience with coefficients presented in standardised form.

6.5.3.3 Comparison of models

To further test the adequacy and validity of the hypothesised model, the three-factor model was tested against an independence model (no underlying relationships amongst factors), a one-factor model (where all items were collapsed into one global factor), and a series of two-factor models in which all possible combinations of the latent factors were considered. The three possible two-factor model combinations reflect the collapsing of (1) the evaluation of the psychosocial aspects of the crowded situation with evaluation of the ambient environment, (2) the evaluation of the psychosocial aspects of the crowded situation with affective reactions, and (3) the evaluation of the ambient environment with affective reactions. However, only the affective reactions versus the combined evaluation of the psychosocial aspects of the crowded situation and evaluation of the ambient environment model yielded meaningful solutions. Therefore, the other two possible two-factor models were rejected on the basis of all fit indices criteria.

An additional fit index, namely Akaike's information criterion (AIC: Akaike, 1987), was incorporated into the analysis to compare the parsimony and fit of these models. The model with the smallest AIC value indicates the better-fitting model. When comparing non-nested models (as done in this study), the AIC fit index is the more appropriate choice than the chi-square difference because the difference in the chi-square values among the models cannot be interpreted as a test statistic (Kline, 2011). The results of the goodness-of-fit indices for all models tested are presented in Table 6.6.

Table 6.6.

Fit indices for each of the models tested (N = 525)

Model	χ^2 (df)	SRMR (< .08)	CFI (≥ .90)	PNFI (≥.60)	RMSEA (< .08)	AIC (Lowest)
Independence model	1857.379** (170)	.470	.842	.742	.138	1937.379
One-factor model	1361.690** (170)	.052	.888	.783	.116	1441.690
Two-factor model	1009.623** (169)	.049	.921	.807	.097	1091.623
Three-factor model	651.051** (167)	.034	.955	.826	.074	737.051

**denotes significant at $p < .001$ level.

Almost all fit indices for testing the independence model did not meet the recommended criteria, thus the model is easily rejected. The one-factor model provided a worse fit for the data than the two-factor model. On the other hand, the CFI value, which exceeds .95, and the SRMR value for the three-factor model, which is less than .05, were sufficient to allow it to be accepted. Furthermore, the RMSEA of .074 for the three-factor model indicates that the model is an adequate fit for the data (Byrne, 2009). These findings suggest that the three-factor model provides the best fit to the data in comparison to other models. This conclusion is further supported by the best parsimonious fit (PNFI = .826) and the lowest Akaike's information criterion value (AIC = 737.051), which indicate that the three-factor model is better fitting and more parsimonious than the other models tested.

6.6 Discussion

The study reported in this chapter discussed the development of an instrument that captures the dimensionality and measurement of rail passenger crowding. The adequacy and validity of the proposed instrument was tested on 525 commuters using rigorous statistical analyses in order to ensure that the instrument possesses desirable psychometric properties, including internal consistency, indicator reliability, composite reliability, and convergent and discriminant validities in its factor structure.

An iterative refinement of the dataset by means of exploratory and confirmatory factor analysis, reliability and validity analysis, as well as SEM analyses resulted in the development of a three-factor instrument that was considered to reflect potentially important components of the crowding experience. Derived constructs, identified as the evaluation of the psychosocial aspects of the crowded situation, the evaluation of the ambient environment of the crowded situation, and affective reactions to the crowded situation, were found to demonstrate good model fit and possess sufficiently good construct, convergent, and discriminant validity values. Therefore, *Hypotheses 1a* and *1b* were supported.

The instrument developed in this thesis is concordant with the work of Kalb and Keating (1981), which suggests a distinction between the crowding experience, the essentially psychosocial characteristics of the crowded situation, and those of its ambient environment. Consisting of 20 items, the present instrument is both multidimensional and sufficiently robust to represent the underlying theoretical constructs of the crowding experience. Further, the instrument's factorial structure confirms the value of considering descriptive, ambient, and affective components in assessing how individuals conceptualise their crowding experiences.

The descriptive dimension of crowding experience has already been established in detail through research of environmental stressors (Evans & Cohen, 2004; Bell et al., 2001). This is reflected in the first component of the present instrument: the evaluation of the psychosocial aspects of the crowded situation. This component consists of seven items that characterise negative evaluations of the density level experienced by individuals such as dense, disorderly, confining, chaotic, cluttered, disturbing, and unpleasant. Substantial research has shown that individuals are more likely to perceive high-density situations as crowded, and when these situations are inherently unpleasant or uncontrollable, high density may affect both perceived crowding (Cox et al., 2006; 2003) and induce affective feelings of crowdedness (Bell et al., 2001; Baum & Paulus, 1987).

The ambient dimension associated with the evaluation of the physical environment of the crowded setting was reflected in four items: hot, noisy, stuffy, and smelly. Research has established that heat, when combined with high-density conditions, contributes to aggressive behaviour and negative interpersonal responses (Griffitt & Veitch, 1971). Similarly, a study by Braun and Parsons (1991) supports this evidence, as they discovered that there is a tendency to associate heat, odour, and discomfort with the feeling of crowdedness.

The affective dimension of the instrument focuses on the individual's experiential feeling state in crowded situations. Its nine items were designed to be associated with behavioural constraint, interference, and stress. Behavioural constraint is reflected in items that describe restricted and hindered feelings, while distraction and frustration are indicative of feelings of being interfered with and disappointment. Stress, however, is characterised by uncomfortable feelings such as discomfort, irritability, stress, and tenseness. Researchers such as

Stokols (1972a; 1972b), Kalb and Keating (1981), and Cox et al. (2006), among others, report that the individual's perception of the aversive experiential state or feeling of crowdedness is linked to constraint, distraction, discomfort, and stress.

Taking these findings together, it can be concluded that the instrument developed in this study has demonstrated promising evidence of reliability and validity for the measurement of the crowding experience among rail users. The instrument was established by taking a new theoretical approach and employing comprehensive methodology to assess the different psychological mechanisms underlying individuals' experience of crowding. In addition, the current study offers three significant advancements in the topic area. First, the development of this instrument clarifies and makes concrete the meaning of "crowding experience", thus providing a specific operational definition of the construct. Second, a reliable and valid instrument with psychometric properties has been introduced which could lend itself to future research in the field; and finally, an instrument that adequately reflects the experience of crowding among rail users could be used as an assessment tool to aid rail operators as well as relevant authorities in addressing the issue of passenger crowding.

6.7 Chapter summary and conclusions

As discussed earlier in the preceding chapters, much of the literature reveals that there is a lack of an agreed-upon scale that taps the entire range of crowding experience. With the development of this new instrument, some of the theoretical and measurement limitations highlighted in previous studies have been addressed, providing this instrument with some advantages over previous measurements. The results of the statistical analyses showed that the instrument developed in this study is capable of reliably and validly measuring the different psychological components that construct the experience of crowding. Having established the psychometric soundness of the proposed instrument, the next chapter proceeds to test the rest of the research hypotheses, particularly examining the relationships among the different psychological components of crowding and their direct and spillover effects on commuters.

CHAPTER 7 – PASSENGER SURVEY

7.1 Chapter overview

This chapter presents the results of Phase Two of the research programme that was collected from a passenger survey. The general background and context of the study are first discussed in Section 7.2 and the objectives are then presented in Section 7.3. This is followed by a description of the method used in this study, including information about the study participants, data collection procedures, measures, data analyses, and statistical treatments conducted to analyse the data (Section 7.4). Next, the findings of the study are presented in Section 7.5. Major findings are then interpreted and synthesised in light of the study's research questions, literature review, and operational model in Section 7.6. The chapter concludes with a summary of the results and considers how these findings answer each of the five research questions posed earlier in Chapter 3.

7.2 Introduction

The findings of the first study (the key stakeholder scoping survey) underscored three important issues for this thesis. First, by examining hard data on passenger loading and train capacity as well as ridership statistics, the study validates our perceptions of the existence of a rail passenger crowding issue in Kuala Lumpur, Malaysia and justifies the need for and relevance of this research work within this setting. Second, it provides background information concerning rail passenger services in Malaysia, which consequently helps to improve the questionnaire design and the study measures for the subsequent study in Phase Two. Third, we understood too that passenger crowding is not the main issue (relative to other priorities) which challenges key stakeholders in the Malaysian rail industry.

While the key stakeholder scoping survey provided important insights, what it did not solicit is the perceptions and experiences of rail passenger crowding amongst the most important stakeholder group - the passengers. Therefore, Phase Two of this research programme was designed to fill in the gaps left by Phase One by collecting data on demographical and commuting characteristics, crowding experiences, and the associated effects from rail users. Consequently, the present study was constructed as a cross-sectional, correlational field research with the intent of examining the relationships among the different psychological components of crowding and their direct and spillover effects on commuters.

The discussions in previous chapters (particularly Chapters 1, 2, and 5) have revealed that passenger crowding is a real concern not only for those using rail transport but also for those who manage rail systems worldwide. Despite this, a large gap remains in our understanding of the pathways and mechanisms of its process and the potential spillover effects that it might have on commuters. It is clear, however, that the commuting experience can spill over to work and home domains and consequently affect individual health and organisational behaviour and well-being (Cox et al., 2006; Koslowsky et al., 1995; Novaco et al., 1990).

Spillover effects of commuting have been found to be associated with a variety of individual work and organisational outcomes, including work-related stress, lost work days, late arrival at work, and workplace aggression (Cox et al., 2006; Koslowsky et al., 1995; Novaco et al., 1990; Hennessy, 2008). Such spillover may also lead to job location change (Novaco, 2001). Additionally, spillover may affect other important aspects of commuters' lives. In a series of studies on the relationship between travel impedance and commuting stress, Novaco et al. (1991; 1990) found that stressful driving conditions can spill over into home life, creating a more negative mood at home in the evening. Similarly, Wener and Evans (2004) show that longer and more arduous commutes are associated with an increasingly greater negative effect on mood.

The spillover effect of crowding was introduced in Cox et al.'s (2006; 2003) model of passenger crowding, stress, and health and safety, as discussed earlier in Chapters 2 and 3. Nevertheless, as highlighted in the previous chapters, the development of Cox et al.'s model has been constrained by a lack of empirical data to test its use as a tool for both understanding passenger crowding and investigating its possible spillover effects. Therefore, one of the aims of the present study was to provide empirical validation for this model.

7.3 The current investigation

Since the focus of this study was on the current perceptions and experiences of rail passenger crowding among commuters, a cross-sectional field study design was appropriate for this endeavour. Another reason for using this design was its ability to examine multiple outcomes at a particular point in time in a relatively quick, easy, and inexpensive way, while simultaneously allowing a thorough exploration of the research questions.

Using such a design, the present study aims to extend the findings of the key stakeholder scoping survey by further addressing the main objectives of the thesis: (1) to examine how and in what direction does the relationships among the different components of crowding experience, passenger density, stress, and feelings of exhaustion are manifested; (2) to investigate how well does commuters' experiences of crowding together with their ratings of passenger density predict stress and feelings of exhaustion; (3) to examine the possible spillover effects of crowding stress and exhaustion on both individual well-being and organisational behaviour; and (4) to identify possible interventions, as suggested by respondents, that might resolve issues associated with rail passenger crowding.

7.4 Method

7.4.1 Participants

Data were collected from commuters on four rail lines serving Kuala Lumpur, Malaysia using a stratified quota sampling procedure. The four lines involved include two LRT (Kelana Jaya line and Ampang line) and two commuter rail services (KTM Komuter Sentul-Klang line and KTM Komuter Rawang-Seremban line). The target sample sizes were determined in such a way that they would closely correspond to the actual daily ridership of the rail lines selected (see Table 7.1). Only passengers who commuted to work regularly using the specified rail services for at least three days each week and have been on the same route for at least six months were eligible to participate.

Table 7.1.

Responding commuters and the daily ridership population

Line	Daily ridership (%)	Targeted (%)	Obtained (%)
Kelana Jaya	170,000 (41.5)	250 (41.6)	271 (51.6)
Ampang	150,000 (37.0)	200 (33.3)	94 (17.9)
KTM Komuter Lines	90,000 (21.5)	150 (25.0)	Sentul-Klang: 52 (9.9) Rawang-Seremban: 20 (3.8)
Transfer/transit	-	-	88 (16.8)
Total	410,000 (100)	600 (100)	525 (100)

A total of 625 respondents participated in this study, an overall response rate of 89.3% from the 700 sets distributed. From this sample pool, 525 respondents met the inclusion criteria and were included for analysis. The 100 participants excluded were either students, were more likely to be infrequent rail users, or had considerable missing data.

The mean age of the participants was 27.7 years (SD = 7.3); 63.2% of respondents were female. More than half of the respondents (77.5 %) have at least a diploma, undergraduate, or postgraduate degree and have been using the rail services for one to four years (46.9%). These sample figures are representative of the user profile of rail users in Malaysia (Yusoff, 2008). The average work commute duration and the average home commute duration were about 33 minutes and 36 minutes respectively. However, the duration of the commuting was reported to be longer (between 61 to 130 minutes) when there are incidences such as trains facing technical problems, overcrowded coaches, train cancellations, or service interruptions.

The distribution of the sample across lines was: 51.6% using the Kelana Jaya line, 17.9% using the Ampang line, 9.9% using the KTM Komuter Rawang-Seremban, and 3.8% using the KTM Komuter Sentul-Klang. The remaining 16.8% of the sample was commuters who normally changed between trains or to other transportation to complete their journey to work.

7.4.2 Data collection

The questionnaires were distributed at organisations located within the survey area of 800 metres around each respective rail station. The strategy for identifying the likely catchment areas was derived from studies conducted by the UK GMPTE Research and Intelligence (2006). Figure 7.1 presents the survey catchment areas.

A team of enumerators (49 university students and graduates) completed four training sessions wherein they were trained to administer the questionnaires and to ensure complete understanding of the survey and its procedure. All enumerators were offered a small remuneration for each completed questionnaire returned by the respondents. The researcher allowed four weeks for the questionnaire to be returned.

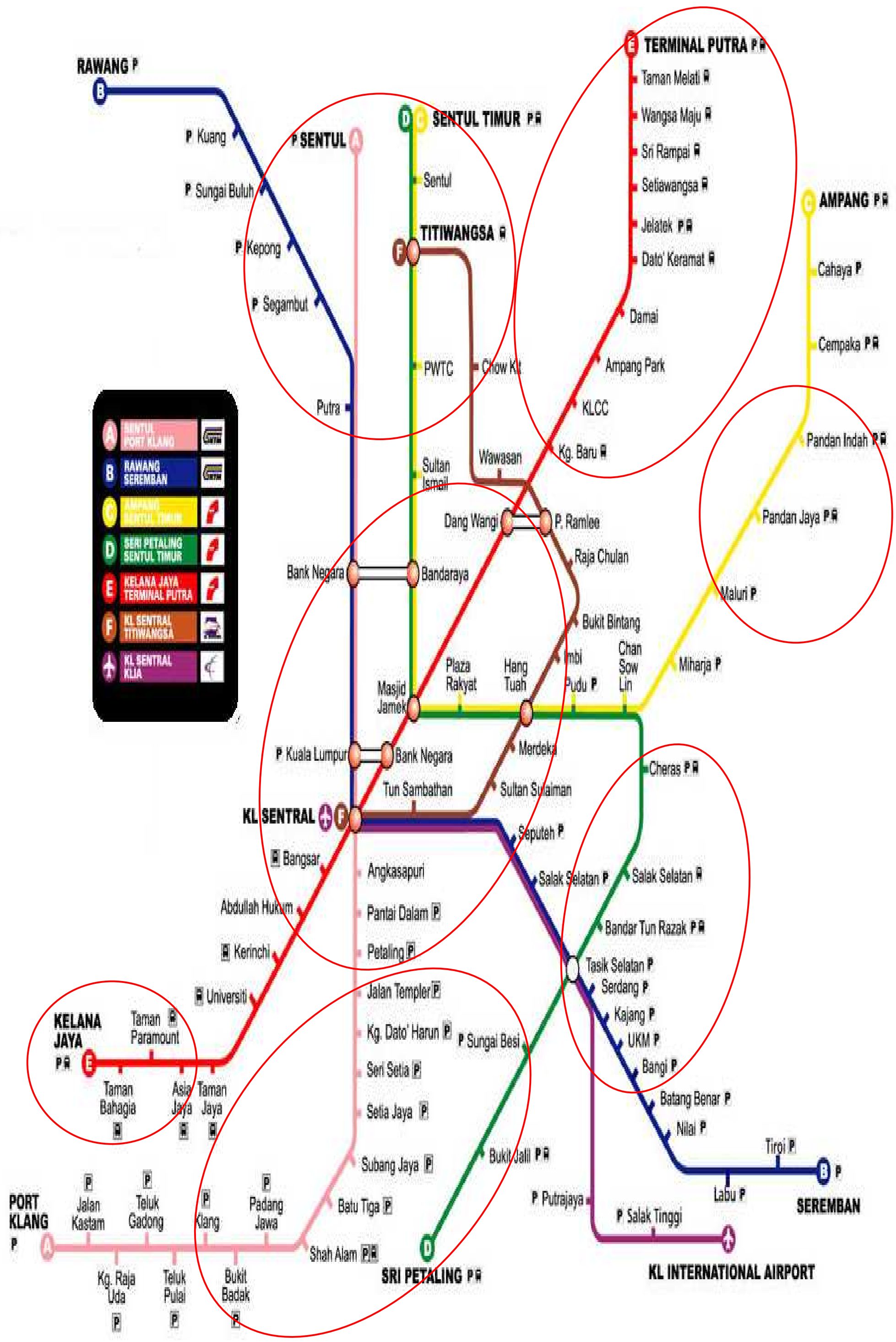

Figure 7.1. Survey catchment area.

7.4.3 Questionnaire

It was crucial to collect and combine the objective data from the passenger density measurement with more in-depth and structured questions assessing the commuters' experience of crowding, along with its possible direct and spillover effects on commuters. This was achieved through administering passenger surveys, using a detailed questionnaire to record the different psychological components of crowding and how these components interact with passenger density and consequently influence the experience of stress, feelings of exhaustion, and spillover effects.

The questionnaire used in this phase primarily consisted of structured questions categorised into six parts. The first part of the questionnaire aimed to gather commuting profile information. Questions covered topics such as the name of the rail line used, frequency and duration of the commute, waiting time per train, typical seating availability, service reliability, and possible crowding mitigation initiatives.

Part two of the questionnaire asked about commuters' journey on the day they completed the questionnaire, which included questions on departure and arrival information and destination points. This part also included questions on passenger density and measures of crowding experience; both of which acted as predictor variables in the model. Meanwhile, Section C in part two and Section I in part five contained measures of stress and feelings of exhaustion as direct outcome variables.

In the third part, respondents were asked about their commuting experience in terms of personal space, perceived uncontrollability over one's commute, unpredictability of the commute, perceived effort expended during the commute, mood state during the commute, and individuals' efforts to cope with the various demands related to commuting. These items were included as control variables in this study.

Questions in Section E along with items in the fourth and fifth parts of the questionnaire were designed to assess the spillover effects of rail passenger crowding. More specifically, Section E dealt with items pertaining commuters' experiences of somatic symptoms that are seen as resulting from the commuting experience, while Section F in part four consisted of items on lateness and absenteeism at work due to the commute. In addition, Section G and Section H contained the intention to quit scale and job satisfaction scale respectively, while Section J in part five contained items that assessed life satisfaction. The final part of the questionnaire (Part 6) contained items related to the participants' demographic characteristics and their contact information as well as comments regarding the questionnaire or other issues related to rail services.

The entire questionnaire was administered in English mainly because English is a well-understood language in Malaysia, particularly in the occupational setting. The details of each scale used in this study are presented in the following section. More specifically, the scales used to measure the experience of crowding and passenger density are discussed in Section 7.4.4.2 and Section 7.4.4.3, while a discussion of the scales used to measure the outcome and control variables is presented in Sections 7.4.4.4 through 7.4.4.7. The complete questionnaire is appended as Appendix E. Meanwhile, Table 7.2 provides an overview of the psychometric properties and reliability scores for each variable tested in the present study.

Table 7.2.

Psychometric properties of the study variables (N = 525)

Variable	M	SD	α	N of items	Range	
					Potential	Actual
Predictor variable: Experience of crowding						
Evaluation of the psychosocial aspects of the crowded situation	20.09	6.79	.94	7	7 - 35	7 - 35
Evaluation of the ambient environment	10.22	3.88	.87	4	4 - 20	4 - 20
Affective reactions to the crowded situation	24.84	9.52	.97	9	9 - 45	9 - 45
Predictor variable:						
Passenger density	2.71	.92	-	1	1 - 4	1 - 4

(continued)

Table 7.2. (continued)

Variable	M	SD	α	N of items	Range	
					Potential	Actual
Direct outcome variables						
Stress (SACL)	9.66	4.18	.81	18	0 - 18	0 - 18
Feelings of exhaustion (GWBQ: Worn-out)	21.42	6.84	.87	12	0 - 48	4 - 43
Spillover effect variables: Individual						
Life satisfaction (SWLS)	22.04	5.37	.82	5	5 - 35	6 - 34
Somatic symptoms	4.08	2.42	.59†	14	0 - 14	0 - 11
Spillover effect variables: Organisational						
Job satisfaction (MSQ)	59.08	12.90	.94	20	20 - 100	21 - 98
Intention to quit	11.93	5.28	.85	5	5 - 30	5 - 28
Commuting-related absenteeism	.62	1.23	.65	2	0 - 28	0 - 7
Commuting-related lateness	6.38	4.80	.60†	4	0 - 28	0 - 21

(continued)

Table 7.2. (continued)

Variable	M	SD	α	N of items	Range	
					Potential	Actual
Control variables						
Personal space	22.55	4.93	.87	5	5 - 30	9 - 30
Perceived control	21.13	4.42	.72	5	5 - 30	9 - 30
Commute unpredictability	20.58	4.70	.82	5	5 - 30	7 - 30
Perceived effort expended	22.05	4.733	.85	5	5 - 30	8 - 30
Mood state	19.61	4.74	.80	5	5 - 30	8 - 30
Coping	19.60	4.54	.58[†]	6	6 - 36	7 - 32

[†] While most of the scales have acceptably high alphas, it is evident there were three Cronbach's alpha values that are equal to or slightly lower than .60 (Commuting-related lateness, Somatic symptoms, and Coping), which is regarded by some as falling below acceptable internal consistency range (e.g. George & Mallery, 2011). However, Nunnally and Bernstein (1994) as well as Garson (2011) advocate that a cut-off of .60 is acceptable as the lower limit for an exploratory study.

7.4.4 Measures

7.4.4.1 <u>Demographic information</u>

The following information was collected from each commuter: age, gender, occupation, education level, and marital status. General commuting questions were also asked. For example, the duration of the commute was assessed by asking, "On average, how long does it take you to commute from home to work?" and "On average, how long does it take you to commute from work to home?" Besides that, respondents were asked how long and how often they have been using the rail lines on a regular basis, how long it takes them to commute one way on a good and bad day, how long they usually have to wait for their train, and how often they encounter delays during their commute to work. These items were included so that the characteristics of respondents could be analysed specifically on the commuting-related variables.

7.4.4.2 Predictor variables: The experience of crowding

The experience of crowding was measured using the new 20-item scale incorporating three subscales as developed and described in Chapter 6. The coefficient alphas for each subscale exceeded .80, indicating that the scales are acceptably reliable: respondents' evaluation of the psychosocial aspects of the crowded situation (α = .94) and of its ambient environment (α = .87), and their affective experience of crowding (α = .97). Higher scores on the three subscales indicated a more negative response.

7.4.4.3 Predictor variables: Passenger density

Passenger density was measured using a pictorial device developed from that used by the UK Rail Safety and Standards Board (RSSB, 2004). Respondents were presented with a scale made up of four pictorial representations of commuters of increasing passenger density. They were asked to use this scale to rate the overall crowd density in the trains. This item, therefore, served to cross-check the validity and consistency of the crowding measures with the objective measure of passenger density.

7.4.4.4 *Direct outcome variables: Stress and feelings of exhaustion*

Passenger stress and feelings of exhaustion were measured using the stress subscale of the Stress and Arousal Checklist (SACL: Gotts & Cox, 1988) and the worn-out subscale of the General Well-Being Questionnaire (GWBQ: Cox & Gotts, 1987) respectively. The SACL is a validated tool for measuring stress and arousal levels and has been used in a number of contexts (Mc Loughlin et al., 2005). However, only the stress scores were used in the data analysis. The scale consists of 18 adjectives describing feelings and moods, with some adjectives loaded positively on stress (for example, tense; worried) and some negatively (for example, calm; cheerful). Responses are made on a four-point scale that assessed how accurately each adjective matches the respondent's current state, producing a range from 0 to 18, with higher scores reflecting greater psychological stress. The reliability of this scale, as measured by internal consistency, is relatively good (α = .81), albeit only marginally lower than those reported elsewhere (for example, Cox & Griffiths, 2005).

The worn-out subscale of the GWBQ was devised to assess suboptimal health, characterised by the feelings of exhaustion (Cox & Gotts, 1987). The scale consists of a list of 12 non-specific symptoms of ill health, including symptoms relating to tiredness, emotional lability, and cognitive confusion. For each item, respondents rated the frequency of occurrence of each symptom with reference to a six-month time window on a five-point scale ranging from 0 (*Never*) to 4 (*All the time*). Individual item scores are summed to produce a reported score of between 0 and 48. A score of 25 or more indicates being worn out or experiencing greater mental exhaustion (Morley-Kirk & Griffiths, 2003). In the present study, the Cronbach's alpha for this scale was .87, consistent with those reported in Cox, Oliver, Rial-González, Tomas, and Griffiths study (2006).

7.4.4.5 Spillover effect variables: Individual domain

Individual spillover effects were measured using the five-item Satisfaction with Life Scale (SWLS: Diener et al., 1985). The scale assesses global cognitive or judgmental aspects of subjective well-being, which reveals the individual's own judgments of his or her life satisfaction. Each item is rated on a seven-point scale ranging from 1 (*Strongly disagree*) to 7 (*Strongly agree*). Scores are summed across items to produce a single score, which varied from 5 to 35. Higher scores indicate more satisfaction with life. Past research has found this scale to demonstrate good test-retest reliability and convergent validity when compared to other measures of life satisfaction validity in a variety of age groups and settings (Pavot, Diener, Colvin, & Sandvik, 1991). Cronbach's alpha for this scale was .82, similar to that reported by Pavot and Diener (1993).

Somatic symptoms that are seen as resulting from the commuting experience were assessed using items taken from the work of Kluger (1998). Some examples of symptoms that were asked about include headache, tiredness, anger, lower back pain, nervousness, and stiff muscles. Responses were "*No*" and "*Yes*", which were scored as 0 and 1 respectively. Items with "*Yes*" responses were summed to create a total symptom score, producing a range from 0 to 14, with higher scores representing greater symptoms. Cronbach's alpha for this scale was .59. Due to the study's exploratory nature, this was judged to be acceptable although lower than .84, as reported in Kluger's study.

7.4.4.6 Spillover effect variables: Work domain

Work spillover was measured using four scales. First, job satisfaction was measured using the Minnesota Satisfaction Questionnaire (MSQ: Weiss et al., 1967). The MSQ scale has 20 items and each item presented the respondent with five response alternatives, which ranged from 1 (*Not satisfied*) to 5 (*Extremely satisfied*). The administration of the scale can yield three scores: (1) general job satisfaction score, (2) intrinsic job satisfaction score, and (3) extrinsic job satisfaction score. However, only the general job satisfaction score was used for data analysis in this study. The general satisfaction score involved the use of all 20 items with a potential score ranging from 20 to 100. Higher scores on this scale reflect higher levels of job satisfaction. Here, Cronbach's alpha was .94, which is within the range of internal consistency estimates of .87 to .92 reported in other studies (ASPE, 2005).

Second, the employees' intention to quit was assessed using five items drawn from Crossley, Grauer, Lin, and Stanton (2002) and Stinglhamber, Bentein, and Vandenberghe (2002). Respondents rated their level of agreement with each item on a six-point Likert scale ranging from 1 (*Strongly disagree*) to 6 (*Strongly agree*). The last item (item 5g) was reversed coded during analysis. The items were summed, and a high score indicates a high intention to quit. Cronbach's alpha for this study (α = .85) is only marginally lower than those reported in other studies, for example .89 in Crossley, Bennett, Jex, and Burnfield (2007).

Third, absenteeism was measured by self-reporting the frequency of absence from work (Kessler et al., 2003; Price & Mueller, 1986). For the purposes of this study, absenteeism refers to the non-attendance of employees for scheduled work due to their commute. The two items that measured this variable were phrased as, "In the past four weeks, how many days did you miss an entire day of work because of your commute?" and "In the past four weeks, how many days did you miss part of a work day because of your commute?" Absenteeism is scored as an average numeric value of the two items, with higher scores reflecting higher levels of absenteeism. The choice of a four-week period over which to report absenteeism was based on Johns's (1994) recommendation that this time span appears to be long enough to enhance reliability but short enough to minimise memory loss. In this study, the Cronbach's alpha for this scale was .65, indicating an acceptable level of internal consistency.

Fourth, lateness to work due to the commute was assessed using the average score from a four-item scale adapted from Kluger (1998). Higher scores indicate more frequent lateness. A sample item is "In the past four weeks, how many days have you been late to work due to your commute?" The rationale for selecting a four-week period over which to report lateness is similar to that of absenteeism; that is, to limit problems related to the span of attention and memory recall. Cronbach's alpha for this scale in this study was .60.

7.4.4.7 Control variables: Between the experience of crowding, passenger density, and direct outcomes (experience of stress and feelings of exhaustion)

The six control variables, which can potentially influence stress reactivity to a crowded commuting experience, are conceptually defined and discussed in Section 3.6.5 in Chapter 3. Here, the items for these variables were operationalised using 31 items that cover six domains: lack of personal space, perceived uncontrollability over one's commute, unpredictability of the commute, perceived effort expended during the commute, mood state during the commute, and individuals' efforts to cope with the various demands related to commuting.

All items were drawn from Kluger (1998) and Wener and Evans (2004) and measured on a six-point scale ranging from 1 (*Strongly disagree*) to 6 (*Strongly agree*). With the exception of the coping scale, which had six items, the remaining control variables were made up of five items each. Each domain score is calculated by summing its individual items, with high scores reflecting higher levels of the commuting experiences that pertain to the respective domain. In this study, the alpha coefficient for each of the control variable was .87 (lack of personal space), .72 (perceived uncontrollability), .82 (commute unpredictability), .85 (perceived effort expended), .80 (mood state), and .58 (coping).

7.4.5 Data analysis procedures

As discussed in Section 4.3.6 of Chapter 4, all data collected were analysed for descriptive analyses, correlations, MANOVA, and regression modelling. Path analysis testing using SEM was then performed to test the hypotheses and the overall model.

7.4.6 Statistical treatment

7.4.6.1 Examination of data entry errors

After all data were entered into an SPSS data file, consistency checks were performed by checking the computerised data file against the original questionnaires. The data-entry errors found in the computerised data file were mainly typographical errors or keystroke mistakes, and these were corrected before the data were analysed. The accuracy of the data was checked using SPSS analyses of descriptive and frequency statistics. An examination of the means, standard deviations, and minimum and maximum values for each variable showed that a minimal number of data were identified as falling outside of the possible range for some of the variables. Incorrectly keyed data items detected through these analyses were checked against the original data from the paper materials and corrections were made accordingly in the SPSS data file. The individual and total scores of each scale were calculated in SPSS using the scoring procedures described for each measure. Approximately 5% of the scores for each scale were also calculated by hand to validate the accuracy of the scoring process. No scoring errors were detected in the dataset.

7.4.6.2 *Missing data*

Five respondents did not report their age. This missing data, however, did not constitute a central problem in the subsequent analyses. The remaining dataset was free of missing data.

7.4.6.3 *Normality*

Field (2005) suggests that visual inspection of histograms and examination of the skewness and kurtosis statistics are more appropriate for evaluating normality of variables with a large number of observations (200 or more) rather than calculating their significance using either the Kolmogorov-Smirnov or Shapiro-Wilk tests. This is because large samples tend to yield relatively small standard errors and, as a result, normality tests can easily detect statistically significant but unimportant deviations from normality (Field, 2005).

In the present study, examination of the histograms demonstrated that the distributions of all variables did not deviate markedly from the bell-shaped normal distribution. However, values of the skewness and kurtosis statistics showed some degree of deviation from normality of the parameter distributions (see Table 7.3). The likely impact of this violation in SEM is that it can increase the value of the chi-square statistic and the standard errors associated with the parameter estimates, while fit indices such as the CFI may yield values that are modestly underestimated (Byrne, 2009).

All variables tested in this study, however, were not transformed in order to maintain the original scale of the data and avoid possible difficulties in interpreting the results. Instead, bootstrapping was applied in the SEM analyses for testing Hypotheses 2 and 4. Byrne (2009) asserts that this method is particularly appropriate for data that comes from non-normal distributions (p. 270). The bootstrapping method gives both the Maximum Likelihood (ML) estimate based on the assumption of normality and a value generated by AMOS that approximates the standard error from the current sample that is not based on this assumption (Byrne, 2009). In doing so, the method allows an assessment of the stability and accuracy of parameter estimates to be made. Nonetheless, the main limitation inherent in bootstrap analysis is that it allows one to make inferences only about the current sample that are not generalisable to other populations (Byrne, 2009). With that in mind, the discussions of the analyses are based on the bootstrapping analysis where the more conservative bootstrap values were reported, and it was noted if they differed from the regular ML estimates.

Table 7.3.

Descriptive statistics of all variables

Items	M	SD	Skewness		Kurtosis	
			Statistic	S.E.	Statistic	S.E.
Demographics						
Age	27.72	7.33	1.788	.107	3.146	.214
Gender	.63	.48	-.551	.107	-1.703	.213
Crowding measures						
Evaluation of the psychosocial aspects of the crowded situation	20.09	6.79	.122	.107	-.475	.213
Affective reactions to the crowded situation	24.85	9.52	.250	.107	-.613	.213
Evaluation of the ambient environment of the crowded situation	10.22	3.88	.370	.107	-.303	.213

(continued)

Table 7.3. (continued)

Items	M	SD	Skewness		Kurtosis	
			Statistic	S.E.	Statistic	S.E.
Rated passenger density	2.71	.92	-.181	.107	-.817	.213
Direct outcomes						
Stress	9.66	4.19	-.289	.107	-.743	.213
Feelings of exhaustion	21.42	6.84	.047	.107	-.088	.213
Spill-over effects						
Individual domain						
Life satisfaction	22.04	5.37	-.422	.107	-.075	.213
Somatic symptoms	4.08	2.42	.736	.107	.043	.213
Organisational domain						
Job satisfaction	59.08	12.90	.182	.107	.541	.213
Intention to quit	11.93	5.28	.590	.107	-.187	.213
Commuting-related absenteeism	.62	1.23	2.596	.107	6.968	.213
Commuting-related lateness	6.38	4.81	.733	.107	-.204	.213

(continued)

Table 7.3. (continued)

Items	M	SD	Skewness		Kurtosis	
			Statistic	S.E.	Statistic	S.E.
Control factors						
Personal space	22.55	4.93	-.444	.107	-.430	.213
Perceived control	21.13	4.42	-.237	.107	-.385	.213
Commute unpredictability	20.58	4.70	-.252	.107	-.216	.213
Effort expenditure	22.05	4.73	-.493	.107	-.188	.213
Mood state	19.61	4.74	.000	.107	-.430	.213
Coping	19.60	4.54	.004	.107	-.285	.213

7.4.6.4 Multicollinearity

An examination of the correlations between the predictor variables revealed that no variables were correlated with each other at a level high enough to suggest multicollinearity. In the regression analyses, the Variance Inflation Factor (VIF) and tolerance were also examined for all variables. Field (2005) states that a VIF value greater than 10 and a tolerance value less than .1 indicate a serious collinearity problem (Field, 2005). An examination of these statistics showed that the VIF values were all less than 5.03 and the tolerance scores were all greater than .1, suggesting that multicollinearity was not a concern.

7.4.6.5 <u>Outliers</u>

Histograms and boxplots of the variables to be included in the analyses were examined to determine the presence of any problematic outliers. Outliers are defined as "cases with such extreme values on one variable (univariate outlier) or a combination of scores on two or more variables (multivariate outlier) that they distort statistics" (Tabachnik & Fidell, 2007, p. 72). No outliers were detected upon a visual inspection of these graphs.

7.5 Results

7.5.1 Characteristics of the study respondents

The profile of the respondents is provided for the entire sample in Table 7.4.

Table 7.4.

Demographic characteristics of respondents

Characteristic	N	%
Age		
17 - 25	257	48.95
26 - 34	191	36.38
35 - 43	40	7.62
44 - 52	25	4.76
53 - 58	7	1.33
Missing	5	1.00
Mean (SD)	27.72 (7.30)	
Gender		
Male	193	36.80
Female	332	63.20
Marital status		
Single	383	73.00
Married	137	26.10
Widowed	2	.40
Divorced	3	.60
Mean (SD)	1.29 (.50)	
Education background		
Primary school	5	1.00
Secondary school	103	19.60
Diploma	129	24.60
Undergraduate degree	215	41.00
Postgraduate degree	63	12.00
Other	10	1.90
Mean (SD)	3.49 (1.03)	

(continued)

Table 7.4. (continued)

Characteristic	N	%
Rail line		
Kelana Jaya line	271	51.60
Ampang Line	94	17.90
KTM Komuter Rawang-Seremban	52	9.90
KTM Komuter Sentul-Klang	20	3.80
Transfer/ transit	88	16.80
Commuting period		
6 – 12 months	165	31.40
1 – 4 years	246	46.90
5 – 9 years	93	17.70
10 years or more	21	4.00
Mean (SD)	2.94 (.81)	

A Multivariate Analysis of Variance (MANOVA) test was performed on the data to determine whether gender had a significant impact on the participants' responses to the crowding and rated passenger density measures. This analysis was conducted to ensure that the crowding experience and rated passenger density were similar for both male and female respondents, after controlling for age.

MANOVA makes the assumption that the variances in each group tested are roughly equal (Field, 2005). Hence, Box's M test was performed to verify that the dataset satisfied this statistical assumption. This test should be nonsignificant if the matrices are the same. Box's test results showed a p value of .44, indicating that there are no significant differences between the covariance matrices; thus the assumption of homogeneity is met.

The MANOVA results showed that there was a non-significant main effect of gender: $F(4, 514) = .276$, $p = .894$, Pillai's Trace = .002.

Similarly, there was a non-significant covariate effect of age on affective reactions to the crowded situation, evaluation of the psychosocial aspects of the crowded situation and of its ambient situation, and rated passenger density: $F(4, 514) = 2.129$, $p = .076$, Pillai's Trace = .016. These results suggest that, after controlling for age, commuters' experiences of crowding and rated passenger density are not affected by gender.

7.5.2 Results of hypothesis testing

The quantitative analyses performed on the questionnaire data are presented in Sections 7.5.3 to 7.5.6. These sections correspond to the four research objectives of this thesis.

As described earlier, the data were examined using descriptive statistics to ensure the accuracy of the dataset, to develop profiles of the total sample, and to identify the distribution of the sample before testing the hypotheses. Next, correlational analysis was performed using Pearson's correlation coefficient to determine the nature and strength of the relationships between crowding measures and all theoretically-related study variables. These results, which are presented in Table 7.5, showed that the crowding measures were significantly correlated with each other as well as with the other predictor variable, rated passenger density. With the exception of job satisfaction, correlations among the crowding measures and the other study variables are in the expected directions and, for some, relatively substantial (> .50).

Table 7.5.

Correlations among study variables

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Evaluation of the psychosocial aspects	1	.85**	.70**	.67**	.54**	.18**	-0.04	.26**	.12**	0.05	.12**	.17**	.42**	.21**	.31**	.36**	.38**	.22**
2	Affective reactions		1	.78**	.64**	.61**	.21**	-0.00	.33**	.14**	0.08	.16**	.19**	.46**	.25**	.35**	.43**	.47**	.24**
3	Evaluation of the ambient environment			1	.48**	.51**	.18**	-0.03	.35**	.11*	0.02	.23**	.18**	.35**	.21**	.35**	.36**	.43**	.23**
4	Rated passenger density				1	.43**	.01*	-0.00	.19**	.10*	0.00	0.08	.17**	.30**	.19**	.27**	.30**	.31**	.14**
5	Stress					1	.24**	-0.04	.32**	.09*	.10*	.17**	.22**	.41**	.21**	.25**	.41**	.41**	.25*
6	Feelings of exhaustion						1	-.15**	.23**	-.09*	.20**	.15**	.13**	.24**	.10*	.18**	.26**	.29**	.27**
7	Life satisfaction							1	0.07	.23**	-.18**	-0.02	-0.02	.11**	0.08	.09*	0.06	0.07	-0.05
8	Somatic symptoms								1	.12**	.10*	.18**	.27**	.38**	.25**	.32**	.36**	.42**	.21**
9	Job satisfaction									1	-.25**	0	.10*	.13**	.10*	.11**	.09*	.14**	0.03
10	Intention to quit										1	.09*	-0.05	0.06	-0.02	0.01	0.07	.09*	.39**

(continued)

Table 7.5. (continued)

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
11	Commuting-related absenteeism											1	**.159****	**.09***	**0.09**	**.12****	**.148****	**.14****	**.18****
12	Commuting-related lateness												1	**.22****	**.14****	**.19****	**.22****	**.23****	0.07
13	Personal space													1	**.39****	**.45****	**.55****	**.54****	**.34****
14	Perceived control														1	**.45****	**.54****	**.45****	**.17****
15	Commute unpredictability															1	**.56****	**.61****	**.26****
16	Effort expenditure																1	**.74****	**.28****
17	Mood state																	1	**.35****
18	Coping																		1

**. Correlation is significant at the .01 level (2-tailed)

*. Correlation is significant at the .05 level (2-tailed)

7.5.3 Research question two (RQ2) - Hypotheses H2a through H2e

Hypotheses 2a through 2e specifically proposed to explain how and in what direction the relationships between the experience of crowding and rated passenger density affect stress and feelings of exhaustion. Path analysis testing via SEM was performed to test the five hypotheses and the overall model. The hypothesised model is presented in Figure 7.2, where rectangles represent the measured variables. Absence of a line connecting variables implies no hypothesised direct effect.

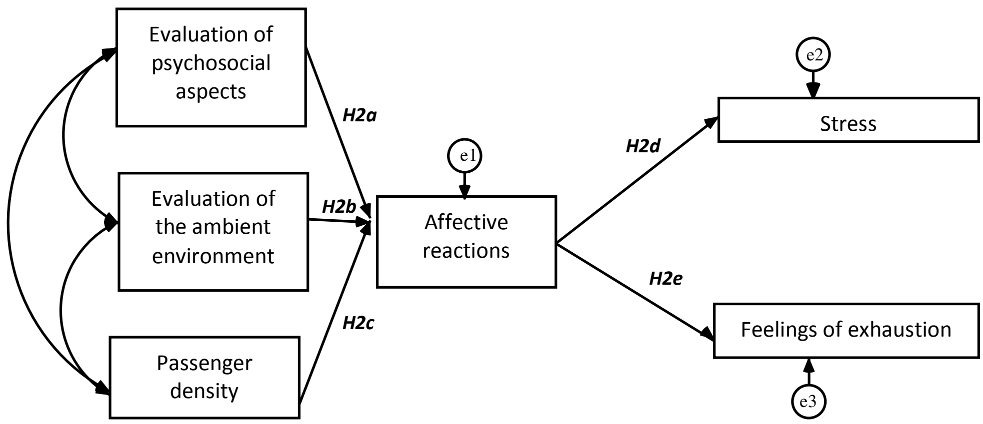

Figure 7.2. Hypothesised model.

The hypothesised model assumed that commuters' affective reactions to the crowded situation are determined, at least in part, by their evaluation of the psychosocial aspects of the crowded situation (*Hypothesis 2a*) and of its ambient environment (*Hypothesis 2b*), and also by rated passenger density (*Hypothesis 2c*). Additionally, it was hypothesised that commuters' affective experience of crowding will in turn determine, at least in part, their reports of stress (*Hypothesis 2d)* and feelings of exhaustion (*Hypothesis 2e*).

Before testing the hypothesised model, we compared the results of including passenger density as the predictor of the experience of crowding in two alternative models. The first alternative model, in which passenger density is assumed to predict commuters' evaluation of the psychosocial aspects of the crowded situation and of its ambient environment and affective reactions to crowding, showed poor fit: χ^2 (n = 525, df = 6) = 779.68, p = .000; SRMR = .182; CFI = .557; PNFI = .223; RMSEA = .496; and AIC = 809.679. See Figure 7.3 for a depiction of these results.

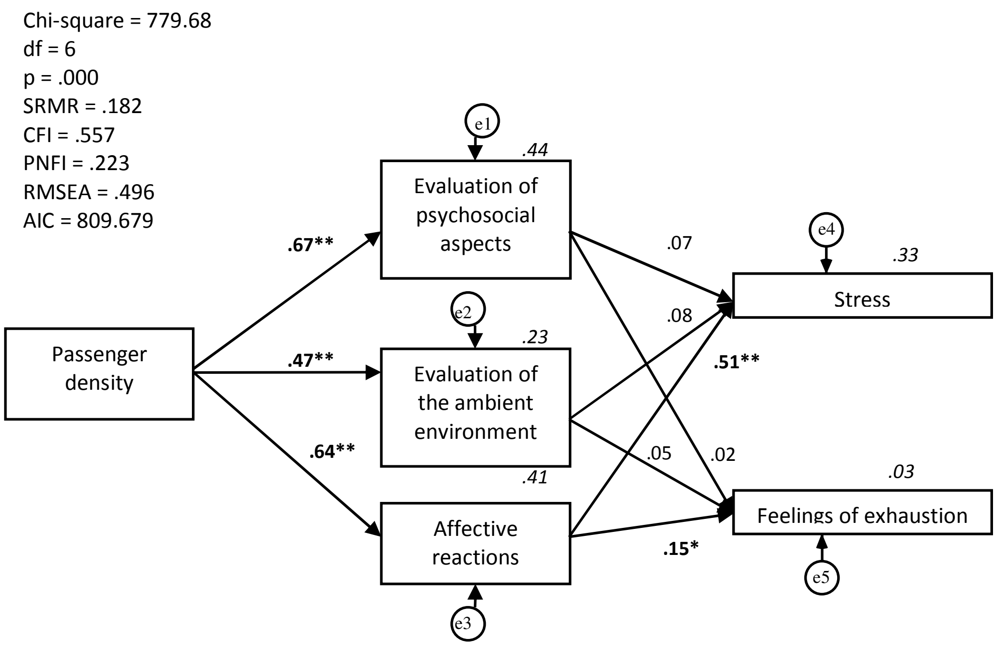

Figure 7.3. Results for the first alternative model, with coefficients presented in standardised form.

Similarly, the second alternative model (see Figure 7.4), wherein commuters' evaluation of the psychosocial aspects of the crowded situation and of its ambient environment are assumed to be predicted by passenger density; these three factors, in turn, are hypothesised to affect commuters' affective reactions to crowding, also yielded poor fit indices: χ^2 (n = 525, df = 8) = 241.88, p = .000; SRMR = .106; CFI = .866; PNFI = .460; RMSEA = .236; and AIC = 267.876.

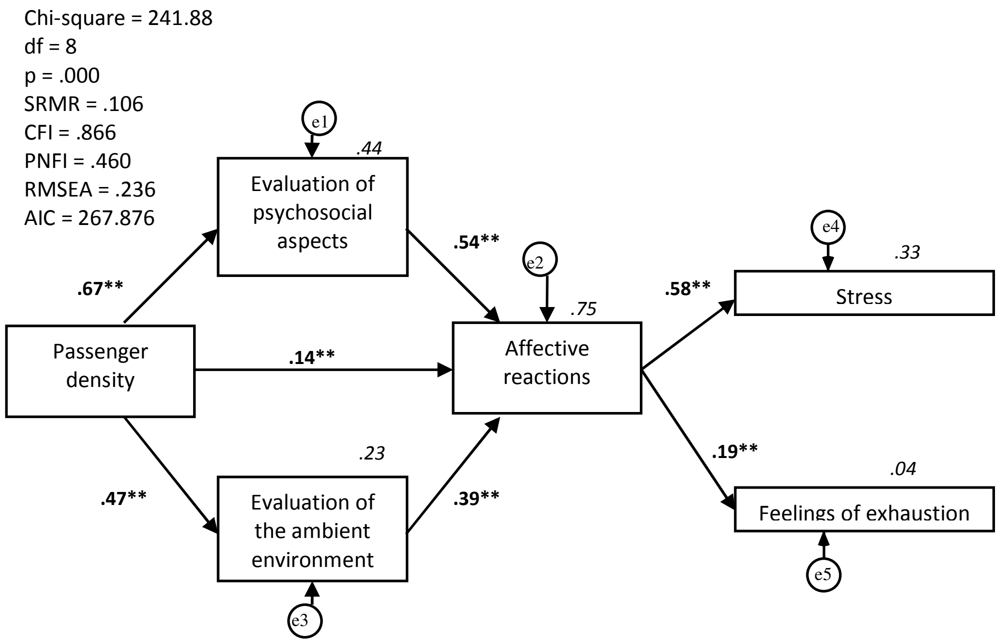

Figure 7.4. Results for the second alternative model, with coefficients presented in standardised form.

These results showed that placing passenger density as a predictor of crowding experience resulted in a degraded model fit. On the basis of these findings, this variable is included as a covariate in the subsequent path analysis models along with two components of crowding experience, which resulted in the current hypothesised model illustrated earlier in Figure 7.2.

All variables defining the hypothesised model (Figure 7.2) were first examined for reliability, validity, and normality. There were complete data for 525 respondents on all variables of interest and no univariate or multivariate outliers were detected. The Mardia kurtosis test found some evidence of departure from multivariate normality: Mardia's value = 2.013; critical ratio = 2.353. Therefore, the models were estimated with bootstrap ML estimation with 500 samples (90% confidence interval) to determine if any of the fit indices or paths varied greatly due to having a moderate degree of kurtosis (Byrne, 2009).

7.5.3.1 Model estimation: Goodness-of-fit indices

Good support was found for the hypothesised model: (SRMR = .029; CFI = .993; PNFI = .462; RMSEA = .058; and AIC = 47.306); although a significant chi-square was observed: [χ^2 (n = 525, df = 7) = 19.306, p = .007]. These results are presented in Figure 7.5.

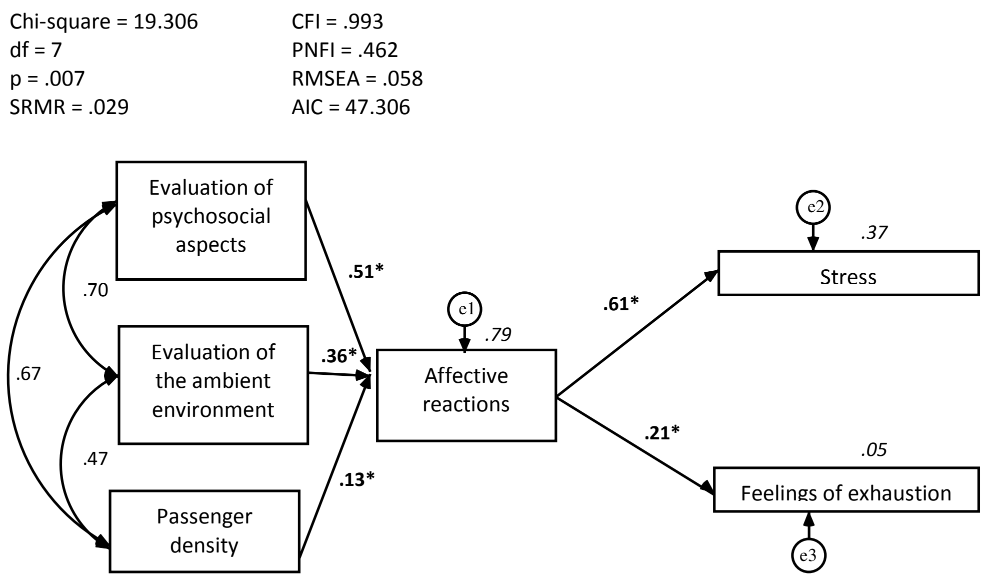

Figure 7.5. Results for the hypothesised model, with coefficients presented in standardised form.

7.5.3.2 *Standardised path coefficients*

In order to test Hypotheses 2a through 2e, the statistical significance of all causal paths in the hypothesised model were examined. Table 7.6 shows the parameter estimates and the hypothesis-testing results.

Table 7.6.

Regression weights[†] of the hypothesised model (N = 525)

Parameter			Unstandardised solutions		Standardised solutions			
			B	**SE**	**β**	**SE**	**Bias-corrected (90% C.I.)**	**p value**
Affective reactions	<-	Evaluation (Psychosocial)	.71	.06	.51	.04	(.44, .57)	.005**
Affective reactions	<-	Ambient environment	.89	.08	.36	.03	(.30, .41)	.007**
Affective reactions	<-	Rated passenger density	1.31	.29	.13	.03	(.09, .18)	.002**
Stress	<-	Affective reactions	.27	.01	.61	.03	(.56, .65)	.003**
Feelings of exhaustion	<-	Affective reactions	.15	.03	.21	.04	(.14, .28)	.004**

[†] Results based on bootstrap ML analysis procedures.

[**] denotes significant at $p < .001$ level.

Squared multiple correlation coefficients (R^2) for: Affective reactions to the crowded situation = .79; for Stress = .37; and for Feelings of exhaustion = .05.

All parameters were significant in the predicted directions. Comparing the bootstrap estimate of the standard error for each factor loading parameter in the model computed across the 500 bootstrap samples with the ML standard error estimates, it was found that all standard errors are similar and biases are low. Additionally, inspection of both the regular ML estimates and the bootstrap ML estimates showed that the bootstrap bias-corrected values did not change the significance of any of the parameters.

The standardised regression weights for the model showed that higher evaluation of the psychosocial aspects of the crowded situation predicted an increasing slope factor for the affective reactions to the crowded situation ($B = .71$, $\beta = .51$, $p < .001$), such that the more the individual evaluated the situation as crowded, the more negative the reported experience of crowding. Thus, *Hypothesis 2a* was supported.

Commuters' evaluation of the ambient environment of the crowded situation also significantly predicted affective reactions to crowding ($B = .89$, $\beta = .36$, $p < .001$), such that a higher evaluation of the ambient environment of the crowded situation led to a greater negative experience of crowding. Hence, *Hypothesis 2b* was supported.

The standardised path coefficients also support *Hypothesis 2c* that affective reactions to the crowded situation is significantly predicted by rated passenger density ($B = 1.31$, $\beta = .13$, $p < .001$). Altogether, 79% of the variance in affective reactions to crowding is accounted for by the combination of these three predictors.

The findings also support *Hypothesis 2d and 2e* that the affective reactions to the crowded situation significantly predicts stress ($B = .27$, $\beta = .61$, $p < .001$) and feelings of exhaustion ($B = .15$, $\beta = .21$, $p < .001$). This suggests that the more unpleasantly crowded the commuters feel, the more stress and feelings of exhaustion they experience. A bulk of the variance in stress (37%) and about 5% of feelings of exhaustion was explained by these predictors.

7.5.3.3 Nested model comparison

To more closely examine the affective reactions to crowding's role in the relationships between crowding, passenger density, and the outcomes, a nested model comparison analysis with a baseline model was conducted (see Figure 7.6).

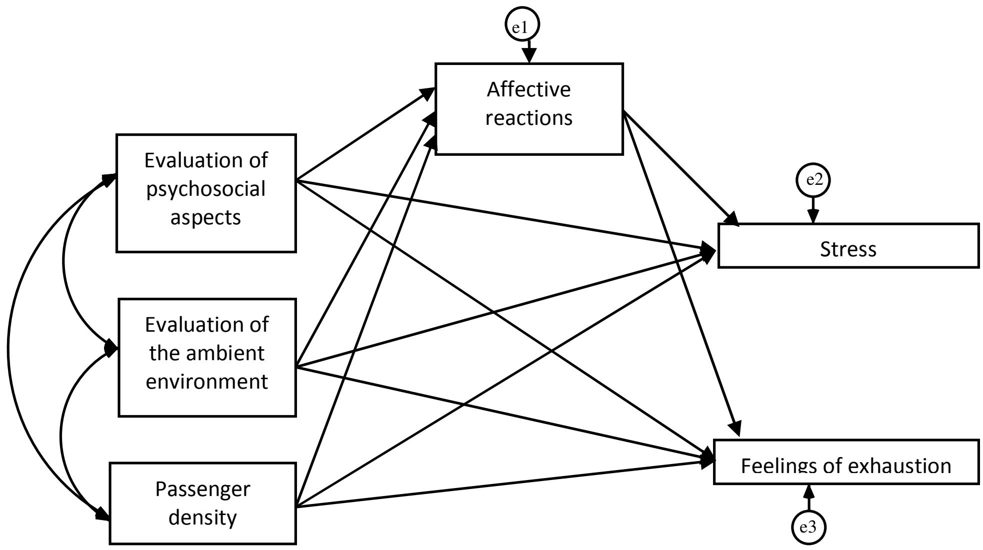

Figure 7.6. Path model for nested model comparison

The posited model depicted in Figure 7.6 contains three nested models. The first is the unconstrained model where all paths among the variables were free to vary (Model 1). Second, a direct path model (Model 2) was assessed. This model incorporates direct paths from (1) the evaluation of the psychosocial aspects of the crowded situation to the outcomes (stress and feelings of exhaustion), (2) the evaluation of the ambient environment to the outcomes, and (3) rated passenger density to the outcomes, while simultaneously constraining all paths to/from affective reactions to crowding to 0. In essence, this direct path model tests for the direct effects of passenger density as well as the evaluation of the psychosocial aspects of the crowded situation and of its ambient environment on the outcomes without the effect of the affective reactions to the crowded situations component. Third, the hypothesised model, wherein all direct paths from the three predictors to the outcomes were constrained to 0, was estimated (Model 3). The chi-square difference ($\chi^2_{difference}$) test was used to compare these models as they are hierarchical models based on the same dataset (Kline, 2011). The presence of a significant $\chi^2_{difference}$ value indicates that the model with more paths explains the data better (Kline, 2011).

The comparison of Model 1 and Model 2 indicates that the unconstrained model provides a better fit than the direct path model ($\chi^2_{difference}$ = 855.649, df = 5, $p < .001$). However, the chi-square difference for Model 1 and Model 3 was not statistically significant ($\chi^2_{difference}$ = 8.191, df = 6, $p = .224$), indicating that Model 3 explains the data equally well compared to the unconstrained Model 1. A closer examination of model fit statistics shows that all fit indices for the hypothesised model (Model 3) improved and the improvement was significant against the unconstrained model, with SRMR, CFI, and PNFI (.029, .993, and .462, respectively), and RMSEA (.058) all at acceptable levels. The hypothesised model also obtains the lowest AIC value (47.306) relative to other models. Together, these results suggest that Model 3 is more parsimonious than other models tested, and is therefore preferred. Table 7.7 provides the comparison of fit indices of these models.

Table 7.7.

Fit indices for the nested model comparison (N = 525)

Model	χ^2 (df)	SRMR (< .08)	CFI (≥ .90)	PNFI (≥.60)	RMSEA (< .08)	AIC (Lowest)
Model 1 (Unconstrained)	11.115** (1)	.024	.994	.066	.139	51.115
Model 2 (Direct path)	866.764** (6)	.320	.507	.203	.523	896.764
Model 3 (Hypothesised)	19.306** (7)	.029	.993	.462	.058	47.306

**denotes significant at $p < .001$ level.

An examination of path coefficients among variables in the baseline/unconstrained model (Model 1) shows that the evaluation of the psychosocial aspects of the crowded situation and of its ambient environment and passenger density have significant effects on affective reactions to the crowded situation as predicted. However, the direct paths linking these predictors to stress and feelings of exhaustion were all statistically non-significant (see Table 7.8). These results demonstrate that neither evaluation of the psychosocial aspects of the crowded situation, evaluation of the ambient environment, nor rated passenger density, were directly related to the experience of stress and feelings of exhaustion.

Following these results, it can be further suggested that there is an interplay among the different components of crowding experience, passenger density, and the outcomes, such that commuters' evaluations of the psychosocial aspects of the crowded situation and of its ambient environment and their ratings of passenger density are related to the experience of stress and feelings of exhaustion, being influenced by their affective experience of crowding.

Table 7.8.

Regression weights† of the unconstrained model (N = 525)

Parameter			Unstandardised solutions		Standardised solutions			
			B	**SE**	**β**	**SE**	**Bias-corrected (90% C.I.)**	**p value**
Affective reactions	<-	Evaluation (Psychosocial)	.71	.06	.51	.04	(.44, .57)	.002**
Affective reactions	<-	Ambient environment	.89	.08	.36	.03	(.30, .41)	.003**
Affective reactions	<-	Rated passenger density	1.31	.29	.13	.03	(.08, .18)	.001**
Stress	<-	Evaluation (Psychosocial)	.02	.05	.03	.07	(-.08, .16)	.643
Feelings of exhaustion	<-	Evaluation (Psychosocial)	.05	.08	.05	.08	(-.07, .18)	.528
Stress	<-	Ambient environment	.09	.06	.09	.06	(.00, .19)	.100
Feelings of exhaustion	<-	Ambient environment	.08	.12	.05	.07	(-.06, .17)	.434
Stress	<-	Rated passenger density	.32	.22	.07	.05	(-.01, .15)	. 146
Feelings of exhaustion	<-	Rated passenger density	-.58	.432	-.08	.06	(-.17, .03)	.234
Stress	<-	Affective reactions	.21	.03	.47	.07	(.34, .58)	.002**
Feelings of exhaustion	<-	Affective reactions	.13	.07	.18	.09	(.02, .33)	.072

† Results based on bootstrap ML analysis procedures.

** denotes significant at p < .001 level.

Squared multiple correlation coefficients (R^2) for: Affective reactions to the crowded situation = .79; for Stress = .38; and for Feelings of exhaustion = .05.

7.5.3.4 *Summary of results pertaining to Research Question Two (RQ2)*

Based on the path coefficient results of the hypothesised model (Table 7.6), it was found that affective reactions to the crowded situation is significantly predicted by commuters' evaluation of the psychosocial aspects of the crowded situation, by their evaluation of its ambient environment, and by their ratings of passenger density. Greater affective reactions to crowding, in turn, significantly predict passenger stress and feelings of exhaustion. Evaluation of the unconstrained (Model 1), direct path (Model 2), and the hypothesised (Model 3) models suggested that the last model was the best fitting model with the most parsimonious explanation of the data. Therefore, the hypothesised model was retained and used in the subsequent analyses.

7.5.4 Research question three (RQ3) – Hypothesis 3 (H3)

In order to examine Hypothesis 3, hierarchical multiple regression analyses were conducted to determine how well the experience of crowding together with rated passenger density predicted stress and feelings of exhaustion ratings of the respondents, by taking into account the potential influences of demographic variables and individual psychological differences in commuting experience. Predictors were entered in blocks in the following order: Step 1: demographic variables, namely age and gender; Step 2: individual psychological differences in commuting experience variables, namely personal space, perceived control, commute unpredictability, mood state, effort expended, and coping; and Step 3: rated passenger density and crowding measures.

With the use of a $p < .001$ criterion for Mahalanobis distance, no outliers among the cases were identified. No multicollinearity in the dataset was found, as there were no substantial correlations ($R > .90$) between predictors. The assumption of independent errors in the regression models was also tenable (Durbin-Watson statistics for stress = 2.02; Durbin-Watson statistics for feelings of exhaustion = 2.06). Five respondents did not report their age; therefore, the following analyses used only complete cases ($N = 520$).

7.5.4.1 Regression analyses

The first analysis showed that a significant effect of crowding and passenger density on stress was obtained after controlling for demographic and individual differences in commuting experience variables. Table 7.9 displays these results.

In step 1, demographic variables accounted for only .4% of the variation in stress (Model 1: R = .06, R^2 = .4%, Adjusted R^2 = .000, F (2, 517) = .93, p = .396). After step 2, the addition of individual difference in commuting experience variables to the equation results in a significant increment in R^2. These predictors accounted for an additional 23.7% of the variation in stress, (Model 2: R = .49, R^2 = 24.0%, Adjusted R^2 = .228, F (8, 511) = 20.18, p < .001). After step 3, with all predictors in the equation, R = .649, R^2 = 42.1%, Adjusted R^2 = .407, F (12, 507) = 30.67, p < .001). Here, the inclusion of crowding measures and rated passenger density added an additional 18% of variation in stress. The final model was significant and the addition of all predictors accounted for 42.1% of variation in the stress scores. This pattern of results suggests that crowding measures and rated passenger density contribute significantly to the prediction of stress. However, individual differences in commuting experience also contribute substantially to that prediction, while age and gender adds no prediction.

Table 7.9.

Regression analyses predicting the experience of stress (N = 520)

Predictor	R^2	Adjusted R^2	R^2 change	B	SE B	β
Step 1	.004	.000	.004			
Age				-.032	.025	-.056
Gender				.197	.380	.023
Step 2	.240	.228	.237**			
Age				-.020	.022	-.036
Gender				-.516	.341	-.060
Personal space				.199	.042	.233**
Perceived control				-.044	.045	-.046
Commute unpredictability				-.080	.046	-.090
Effort expenditure				.181	.056	.205*
Mood state				.167	.056	.189*
Coping				.064	.039	.070
Step 3	.421	.407	.180**			
Age				-.025	.020	-.044
Gender				-.291	.299	-.034
Personal space				.091	.038	.106*
Perceived control				-.028	.039	-.029
Commute unpredictability				-.107	.041	-.120*
Effort expenditure				.135	.049	.153*
Mood state				.068	.050	.078
Coping				.042	.034	.045
Evaluation of psychosocial aspects of the crowded situation				.009	.042	.015
Affective reactions to the crowded situation				.163	.034	.368**
Evaluation of the ambient environment				.093	.060	.086
Passenger density				.356	.211	.078

**denotes significant at p < .001 level.
*denotes significant at p < .05 level.

An examination of the standardised regression coefficients (β) for each multiple regression model was conducted to examine which variables were making a significant contribution to variance in the experience of stress across individuals. In the final model, the findings showed that a significant positive association between affective reactions to the crowded situation and stress ($\beta = .368$, $p < .001$), a significant positive association between effort expended and stress ($\beta = .153$, $p < .05$), a significant negative relationship between commute unpredictability and stress ($\beta = -.120$, $p < .05$), and a significant positive association between lack of personal space and stress ($\beta = .106$, $p < .05$) were obtained when the effects of other predictors are held constant.

The second hierarchical regression analysis showed that demographic variables accounted for 2.3% of the variation in feelings of exhaustion (Model 1: $R = .152$, $R^2 = 2.3\%$, Adjusted $R^2 = .019$, $F(2, 517) = 6.11$, $p < .05$). After step 2, with individual differences in commuting experience variables added to the prediction of feelings of exhaustion, $R^2 = .136$. These predictors accounted for an additional 11.3% of the variation in feelings of exhaustion (Model 2: $R = .369$, $R^2 = 13.6\%$, Adjusted $R^2 = .123$, $F(8, 511) = 10.08$, $p < .001$). After step 3, the inclusion of crowding measures and rated passenger density as new predictors to the equation only added an additional .5% to the explained variation in feelings of exhaustion (Model 3: $R = .376$, $R^2 = 14.1\%$, Adjusted $R^2 = .121$, $F(12, 507) = 6.96$, $p = .557$). The addition of all predictors accounted for 14.1% of variation in feelings of exhaustion. This pattern of results indicates that over 11% of the variability in feelings of exhaustion is predicted by the individual differences in commuting experience, while demographic variables add only modestly to that prediction. Additionally, crowding measures and rated passenger density did not contribute significantly to the prediction of feelings of exhaustion. These results are presented in Table 7.10.

Examination of the standardised regression coefficients (β) of the final model showed coping to be the most important predictor of feelings of exhaustion ($\beta = .170$, $p < .001$). Results also revealed a significant negative relationship between age and feelings of exhaustion ($\beta = -.087$, $p < .05$) and a significant positive association between mood state and feelings of exhaustion ($\beta = .135$, $p < .05$) when the effects of other predictors are held constant.

Table 7.10.

Regression analyses predicting feelings of exhaustion (N = 520)

Predictor	R^2	Adjusted R^2	R^2 change	B	SE B	β
Step 1	.023	.019*	.023*			
Age				-.098	.041	-.105*
Gender				1.572	.615	.111*
Step 2	.136	.123	.113**			
Age				-.081	.038	-.087*
Gender				1.067	.594	.075
Personal space				.087	.073	.063
Perceived control				-.133	.078	-.086
Commute unpredictability				-.010	.080	-.007
Effort expenditure				.137	.097	.095
Mood state				.215	.097	.149*
Coping				.265	.068	.175**
Step 3	.141	.121[6]	.005			
Age				-.081	.039	-.087*
Gender				1.102	.595	.078
Personal space				.062	.076	.044
Perceived control				-.129	.078	-.083
Commute unpredictability				-.007	.081	-.005
Effort expenditure				.132	.097	.091
Mood state				.195	.099	.135*
Coping				.257	.068	.170**
Evaluation of psychosocial aspects of the crowded situation				.044	.083	.044
Affective reactions to the crowded situation				.046	.067	.064
Evaluation of the ambient environment				.003	.119	.002
Passenger density				-.504	.421	-.067

**denotes significant at $p < .001$ level.
*denotes significant at $p < .05$ level.

[6] The slight decrease of the adjusted R^2 value observed in the final model may indicate some overfitting of the regression equation. This presumably happens because the model contains many parameters (Cohen et al. 2003, pp. 83-84). Some techniques are available to correct this (e.g. cross-validation, regularisation, etc.); however, these additional analyses were not carried out because the decrease was small as to be negligible from a practical point of view.

7.5.4.2 *Summary of results pertaining to Research Question Three (RQ3)*

Taken together, the results showed that the inclusion of crowding measures and passenger density in the final model had a significant effect on the experience of stress, even after controlling for demographic and individual differences in commuting experience factors. Given that the effects of other predictors are held constant, stress is more likely to be experienced when the commuting situation is appraised as psychologically crowded, highly effortful, and encroaching upon one's personal space.

The substantial positive correlations between crowding measures and rated passenger density and feelings of exhaustion disappeared when demographic and individual differences in commuting experience factors were partialled out. Instead, feelings of exhaustion are associated with exposure to the commute situation, which requires effortful coping strategies and causes negative moods. Additionally, it appears that the older the commuter, the lower the probability that he or she reported feeling exhausted. Based on these results, feelings of exhaustion were dropped from the hypothesised model and were excluded in the subsequent analyses.

7.5.5 Research question four (RQ4) – Hypotheses 4a and 4b

Research question four assumes that passenger stress and feelings of exhaustion attributed to crowding and density will spill over to impact both work and individual outcomes. However, following the hierarchical multiple regression results of the third hypothesis test, which showed that crowding measures and rated passenger density failed to significantly predict feelings of exhaustion after controlling for demographics and individual commuting experience variables, this variable was dropped from the final model. The hypothesised final model is depicted in Figure 7.7, where rectangles represent measured variables.

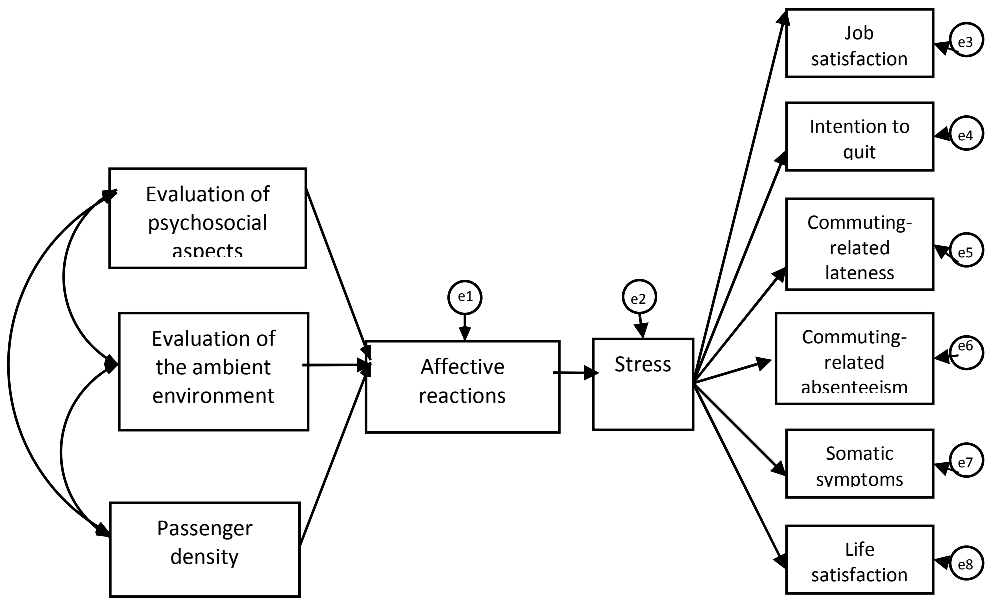

Figure 7.7. Hypothesised final model.

The final model examined the predictors of somatic symptoms of ill health and life satisfaction. It was hypothesised that high experience of stress, as attributed by the joint contributions of crowding measures and rated passenger density, directly predicted a greater number of reports of somatic symptoms of ill health and decreased life satisfaction. In addition, it was hypothesised that high experience of stress, as attributed by the joint contributions of crowding measures and passenger density rating, directly predicted decreased job satisfaction, increased intention to quit, and higher rates of lateness and absenteeism at work.

There were no missing data and the analysis used the complete data set representing 525 participants. No univariate or multivariate outliers were detected. However, there was evidence that multivariate normality was violated. The Mardia's coefficient value for this model was 14.46 with a critical ratio of 9.99, reflecting significant kurtosis. Therefore, the model was estimated with bootstrap ML estimation with 500 samples (90% confidence interval). Comparison of the bootstrap estimate of the standard error for each factor loading parameter in the model however showed that all standard errors are similar and biases are low.

7.5.5.1 Model estimation: Goodness-of-fit indices

The hypothesised final model performed modestly well according to most of the fit indices, indicating adequate model fit: SRMR = .078; CFI = .917; PNFI = .686; RMSEA = .08; and AIC = 254.986. The only exception was the chi-square criterion [χ^2 (n= 525, df = 42) =, p = .001]. The hypothesised final model with standardised coefficients is presented in Figure 7.8.

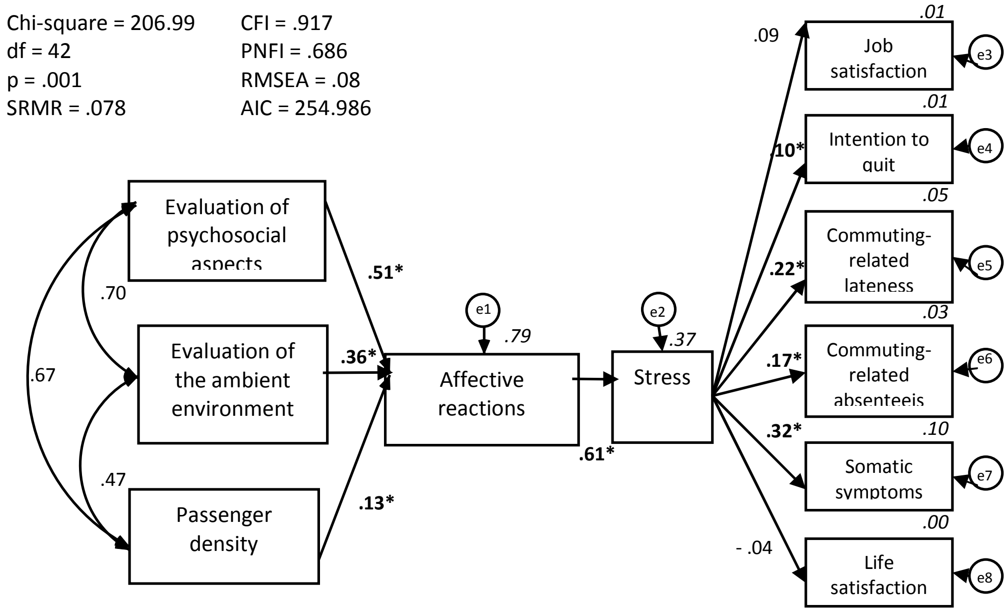

Figure 7.8. Final model with standardised coefficients.

7.5.5.2 Standardised path coefficients

In order to test Hypotheses 4a and 4b, the statistical significances of all causal paths in the hypothesised model were examined. Table 7.11 shows the parameter estimates and the hypothesis-testing results. All parameters were significant in the predicted directions. Inspection of both the regular ML estimates and the bootstrap ML estimates showed that the bootstrap bias-corrected values did not change the significance or the non-significance of any of the parameters.

Table 7.11.

Regression weights[†] of the hypothesised final model (N = 525)

Parameter			**Unstandardised solutions**		**Standardised solutions**			
			B	**SE**	**β**	**SE**	**Bias-corrected (90% C.I.)**	**p value**
Affective reactions	<-	Evaluation (Psychosocial)	.71	.06	.51	.04	(.44, .57)	.005**
Affective reactions	<-	Ambient environment	.89	.08	.36	.03	(.29, .41)	.007**
Affective reactions	<-	Rated passenger density	1.30	.29	.13	.03	(.09, .18)	.002**
Stress	<-	Affective reactions	.27	.01	.61	.03	(.56, .65)	.003**
Job satisfaction	<-	Stress	.28	.17	.09	.05	(-.01, .18)	.122
Intention to quit	<-	Stress	.13	.06	.10	.04	(.03, .17)	.020*
Commuting-related lateness	<-	Stress	.25	.05	.22	.04	(.15, .29)	.005**
Commuting-related absenteeism	<-	Stress	.05	.01	.17	.04	(.11, .23)	.003**
Somatic symptoms	<-	Stress	.19	.02	.32	.04	(.26, .39)	.003**
Life satisfaction	<-	Stress	-.05	.06	-.04	.04	(-.11, .03)	.373

[†] Results based on bootstrap ML analysis procedures.

** denotes significant at p <.001 level.

*denotes significant at p <.05 level.

Squared multiple correlation coefficients (R^2) for: Affective reactions to the crowded situation = .79; Stress = .37; Job satisfaction = .8%; Intention to quit = 1%; Commuting-related lateness = 4.8%; Commuting-related absenteeism = 2.8%; Somatic symptoms of ill health = 10.5%; and Life satisfaction = .1%.

The findings support and refine the *fourth hypothesis*. The standardised path coefficients showed that affective reactions to crowding was significantly predicted by the evaluation of the psychosocial aspects of the crowded situation ($B = .71$, $\beta = .51$, $p < .001$), and by the evaluation of its ambient environment ($B = .89$, $\beta = .36$, $p < .001$), as well as by passenger density rating ($B = 1.30$, $\beta = .13$, $p < .001$). Over 79.0% of the variance in the affective reactions to crowding was accounted for by these three predictors. Affective reactions to crowding, in turn, significantly predicted stress ($B = .27$, $\beta = .61$, $p < .001$), suggesting that the more crowded the individual felt, the greater stress was experienced. A total of 37.0% of variance in stress was explained by the combinations of all crowding measures and rated passenger density as the predictor variables.

Passenger stress attributed to crowding and passenger density predicts the propensity for lateness for work ($B = .25$, $\beta = .22$, $p < .001$) and absenteeism ($B = .05$, $\beta = .17$, $p < .001$) as well as intention to quit ($B = .13$, $\beta = .10$, $p < .05$). Additionally, self-reports of somatic symptoms were significantly predicted by stress attributed to crowding ($B = .19$, $\beta = .32$, $p < .001$). However, passenger stress does not significantly predict job satisfaction ($B = .28$, $\beta = .09$, $p = .122$) or life satisfaction ($B = - .05$, $\beta = - .04$, $p = .373$). The strongest relationship was found between commuters' experience of stress and their report of physical or somatic symptoms (10.5% of variance explained). Stress attributed to crowding also explained 4.8% of the variance in lateness for work, 2.8% of the variance in absenteeism, 1.0% of the variance in intention to quit, .8% of the variance in job satisfaction, and .1% of the variance in life satisfaction.

7.5.5.3 *Summary of results pertaining to Research Question Four (RQ4)*

The final model yielded an adequate degree of fit to the data and the results provide empirical evidence that passenger stress, attributed to crowding, has the potential to spill over to other aspects of the commuters' life and work. These effects are reflected in terms of propensity for lateness and absenteeism at work, intention to quit, and somatic symptoms of ill health.

7.5.6 Research question five (RQ5)

The last objective of this study was to examine possible crowding mitigation initiatives as suggested by the commuters and to determine whether these measures correspond to the interventions proposed by Cox et al.'s model (2006). In a free-response format, respondents were asked about what sorts of initiatives would be most effective in mitigating crowding in the rail transportation setting. A coding system was developed to classify the crowding mitigation initiatives listed by the respondents into a manageable number of categories. Six categories or dominant themes that accounted for the majority of the responses given were created and the free text responses from question 11a (*In your opinion, what could the train operating companies or rail operators do to reduce the feeling of crowdedness experienced by the commuters?*) were examined and assigned to one of these categories.

The first two categories were those involved with rolling stock issues, such as (1) adding extra train and rail capacity, and (2) improving maintenance of the existing rail cars and infrastructure, while the remaining categories offer practical issues on (3) frequency, punctuality, and waiting time of the rail services, (4) improved information provision about service availability, scheduling, and crowding level prior to departure, (5) redesign of the train carriages, and (6) installation of passenger detection systems or tools for detecting crowding level in all train carriages. If a response could not be adequately classified by any of the six categories, it was coded as "Other". These categories are described in Table 7.12.

Many of the responses support the issues highlighted by the key stakeholders discussed in Chapter 5 of this thesis. Providing more train lines or extra coaches appeared to be the most important criteria for mitigating the effects of crowding (N = 233). The majority of those who commented reported that without the added capacity of commuter rail or LRT services, overcrowding will continue to be a problem and the overall quality of rail services will not be significantly improved. Respondents maintained that regular maintenance of trains, stations, and other related infrastructure should be performed to ensure the safety of the rail services and to maximise the reliability, performance, and operational effectiveness of the overall rail systems.

Several interesting results consistent with the type of interventions suggested by Cox et al.'s (2006) model were found. For instance, a sizable majority of respondents felt that the effects of crowding can be considerably mitigated by enforcing punctuality, increasing frequency and scheduling of the rail services, and shortening the waiting time for commuters (N = 131). Many of them reported the inconvenience of delays and cancellations as well as the unreliability of the services. In addition to frequent and punctual services, respondents also desire accurate information about service availability, scheduling changes, levels of crowding on trains and at platforms, and potential alternative routes or modes of transport.

Table 7.12.

Descriptions of crowding mitigation categories used in coding free-response data

Category	Example	Code
1. Add extra capacity	"Provide more train during peak hours, e.g. morning - off to work 6:45- 8:00 a.m., evening - back from work 5:00 -7:00 p.m."	65
	"Increase coach per trip not increase trip. Two coaches per journey are unreliable compared to four coaches per journey. Having this increased, coach will definitely get smooth traffic/passenger flow."	111
	"Provide more trains to operate at peak hours/ weekend/holiday."	228
2. Provide regular and consistent maintenance of all rail infrastructure and train carriages	"Provide regular maintenance of the train."	375
	"Please do maintain the trains often."	232
	"Fix and maintain KTM trains regularly."	465
3. Enforce punctuality, increase frequency and scheduling, and shorten waiting time	"Increase train frequency and avoid delays."	408
	"Increase frequency and punctuality."	73
	"Reduce waiting time by adding frequency of the train (KTM). Enforce good queuing system."	141
4. Provide better communication	"Rail operators should announce five minutes earlier if the train is cancelled or delayed."	203
	"Officers have to counter any arising problem fast and keep the passengers informed."	334

(continued)

Table 7.12. (continued)

Category	Example	Code
5. Redesign of train carriages	"Redesign the coaches to allow more head room for more air circulations."	66
	"Provide more seats that are arranged in rows rather than facing one another."	516
	"Limit the number of passenger per carriage and rearrange the interior of train to seat people in rows."	155
6. Passenger detection systems	"Set an automatic detection system that warns everybody in the train about the number of passengers. The system must set a limit to the total number of passengers who can enter the train, like the lift system."	444
	"Introduce system ticket i.e. number on ticket represent the quota at certain time e.g. 8:00 a.m. trip: ticket number "1012 to "2018"."	457
7. Other		
Upgrade facilities	"Build more stations."	57
Provide alternative transportations	"Other transportation should be used. Busses should be more available at all areas."	78
Provide some forms of on-train entertainment	"Have on-train radio programmes to entertain the commuters. Appropriate advertising might be useful as well e.g. campaign to encourage commuters to smile, to respect the senior citizen."	247
Allocate specific train carriages for women, elderly, and disabled commuters	"Separate the cabin based on gender to avoid sexual harassment."	137
	"I would hope to see dedicated cabins for female, elderly, and other fragile groups."	442

Another approach to mitigating rail passenger crowding suggested by the respondents is that the rail operators could redesign their train carriages to accommodate all passengers, especially at peak hours. The redesign could include removing some of the seats or redesigning the seating layouts to allow for more space and comfort. While a minority of respondents identified the potential use of music and advertisement images to reduce crowding effects, some other respondents suggested that allocation of dedicated carriages to specific user groups such as female, elderly, and disabled commuters would not only mitigate crowding issues but would also address sexual harassment and safety problems on the trains.

7.6 Discussion

The study reported here focused on exploring the relationships among the different psychological components of crowding and on testing the existence of spillover effects on both individual and work outcomes. It collected data from 525 commuters in Kuala Lumpur, Malaysia and used SEM and regression techniques in its analysis. The results made clear the relationships among passengers' evaluation of the crowded situation and of its ambient environment, their affective reactions to it, and the relationships among these psychological components of crowding and passenger density. They also demonstrated that the three measures of crowding experience together with rated passenger density predicted commuters' stress and feelings of exhaustion. While the effects of crowding experience and passenger density on stress remained significant even after controlling for demographic and individual differences in commuting experience factors, their effects on commuters' feelings of exhaustion disappeared when controlled for similar factors.

Following these statistical iterations, a final model was proposed and tested. The final model yielded an adequate degree of fit to the data and the results of the analysis demonstrated the relationships among the three components of crowding, passenger density, and the experience of stress, and confirmed that passenger stress, attributed to crowding, has the potential to spill over to other aspects of the passengers' life and work. In particular, stress spilled over in terms of propensity for lateness and absenteeism at work, intention to quit, and reports of ill health, but not in terms of their job or life satisfaction. The boundaries between these various domains are indeed permeable.

These findings are further discussed in the following order: (1) Research Questions Two and Three (Section 7.6.1), (2) Research Question Four (Section 7.6.2), and Research Question Five (Section 7.6.3).

7.6.1 Research Questions Two and Three

The second and third objectives of the thesis were to generate a statistical model of crowding stress using the experience of crowding and passenger density as predictor variables and to examine whether these effects remain after controlling for other relevant variables. The path analysis results confirm an interplay among the different components of the experience of crowding, passenger density, and the direct outcomes, as commuters' affective feelings of crowdedness are significantly predicted by their evaluations of the psychosocial aspects of the crowded situation and of its ambient environment and by rated passenger density. Greater affective reactions to crowding, in turn, serve as a significant predictor of the experience of stress and feelings of exhaustion.

Prior research has established that individuals tend to experience emotional imbalance, cognitive inconsistency, and physiological stress in crowded conditions (Baum & Paulus, 1987; Stokols, 1972a). The present research work extends these findings by showing that the different psychological components of crowding, together with density, can have an impact on the psychological reactions of commuters. Specifically, commuters are most likely to experience stress and feelings of exhaustion when the following conditions are present: the individual's description and evaluation of the density level are negative, the ambient environment is regarded as unpleasant, and many passengers occupy the train. These effects might occur as a result of feelings that one's behaviour is constrained or infringed upon, loss of control, and being uncomfortable due to the presence of too many other people (Bell et al., 2001; Baum & Paulus, 1987). It is also possible that the very nature of commuting places a significant strain upon passengers in crowded travel conditions, for instance because of services that are unreliable, unpredictable, or effortful in nature (Cox et al., 2006; Wener & Evans, 2004). In the current study, the roles of these variables are not specifically explored. Thus, further research is required to clarify this issue.

Another result of interest is the failure to find a direct effect of passenger density on the outcomes in the present study. Nested model comparison analysis conducted in Section 7.5.3.3 indicates that passengers' stress and feelings of exhaustion were not directly predicted by this variable. This result, to some extent, challenges the popularly assumed link between density and stress and implies that passengers could still experience stress and exhaustion even under what appears to be low-density conditions. Indeed, this evidence supports the proposition that density per se does not necessarily lead to the experience of crowding or to the negative effects associated with crowding (Stokols, 1972a).

A possible explanation for this finding is provided by most integrative models of crowding discussed in Chapter 3. For instance, the equilibrium model of the human response to crowding by Stokols (1972a; 1972b), the privacy regulation model by Altman (1976; 1975), the crowding as a sequential process model by Sundstrom (1978), and the eclectic-behaviour model by Bell et al. (2001) explain that although high-density conditions may lead to adverse outcomes, whether or not they are salient depends upon specified personal, situational, social, environmental, and cultural factors operating within these conditions. Researchers have argued that when the negative aspects of high density are not salient, the environment is perceived to be within an optimal range and no adverse effects occur (Bell et al., 2001). Therefore, it is possible that approaches and interventions targeted at reducing crowd density alone may not be entirely effective in alleviating passenger stress.

Previous research debates the fact that crowding studies struggle to show the link between crowding and health and safety, particularly in a rail setting (for example, Turner et al., 2004; Bottomley, 1999). However, the findings from the regression analysis reveal that the effects of crowding and density on passenger stress remain significant and in the predicted direction even after controlling for demographic characteristics (gender and age) and individual differences in commuting experience (personal space, perceived control, commute unpredictability, mood state, effort expenditure, and coping). In particular, a significant positive association between affective reactions to the crowded situation and stress ($\beta = .368$, $p < .001$) was obtained. This effect can be understood by considering that high feelings of crowdedness have been consistently found to lead to increased negative psychological reactions, higher physiological arousal, reduction of task performance, and a decline in the quality of interpersonal relations in non-rail environments (Bell et al., 2001).

It is also possible that the feeling of a lack of space may be a reason for crowding being associated with stress. There is empirical support for the view that the close presence of others inside public transport evokes the perception of crowdedness, and this, in turn, increases the experience of stress (Evans & Wener, 2007). This situation happens because people feel that their personal space and privacy during the commute have been intruded upon by the close presence of others. Therefore, any attempt at mitigating crowding should allow full consideration of the influence of personal space on the experience of stress by the passengers, and, if possible, design interventions to incorporate these relationships in positive ways.

Contrary to the prediction, the significant relationships among crowding experience, passenger density, and feelings of exhaustion disappeared after controlling for similar demographic and commuting experience variables. Although surprising, this result is not entirely unexpected, since feelings of being worn-out or exhausted are probably the result of prolonged stress and negative emotions due to excessive demands, depletion of resources, and different characteristic coping patterns of individuals (Leiter, 1991) and thus may not be able to adequately explain the ongoing social processes as individuals deal with the high-density conditions. Furthermore, studies in the work-stress literature seem to suggest that factors such as job demands and constraints, work hazards, and work–home interference tend to be better predictors of emotional exhaustion (for example Cox & Griffiths, 2005; Demerouti, Bakker, & Bulters, 2004) rather than environmental stressors. Consequently, it is possible that the effects of crowding in a secondary environment (such as in a transport setting) are not as straightforward as for those involving these organisational factors in producing this feeling.

On a slightly different but related note, the regression analyses also suggest that the models involving individual differences in commuting experience appear to be potentially important in moderating the effects of crowded commuting. While stress reactivity was also heavily influenced by the degree of effort felt during the commute and the perception of predictability of the journey, emotional exhaustion was more affected by individuals' current mood state and age as well as by their efforts to cope with the various demands related to commuting. These findings are in accordance with most studies concerning commuting stress. A journey that is relatively predictable and does not require excessive physical, cognitive, and affective effort is generally judged to be less stressful than a high-effort trip (Wener & Evans, 2011). It follows that commuters are not always motivated to invest extra effort and are not willing to pay the costs of commuting. Similarly, in a series of studies investigating the relationship between commute characteristics and stress effects, Kluger (1998) and Koslowsky et al. (1995) found that the unpredictability of the commute contributes substantially to commuting stress in such a way that it may add to or exacerbate other stressful aspects of a trip.

With regard to feelings of exhaustion, it appears that personal characteristics such as current mood state, age, and individual's coping effort play significant roles in fatigue and exhaustion during the commute. Research by Novaco et al. (1990), who examined commute impedance (that is, a combination of factors that frustrate the goal of arriving at a destination), show that higher impedance is significantly associated with various negative outcomes, including a more negative mood and lower frustration tolerance. Meanwhile, the result that showed the significant relationship between commuters' age and reported feelings of exhaustion is consistent with studies of burnout, which report that age is negatively associated with feelings of emotional exhaustion (Stremmel, Benson, & Powell, 1993). This pattern of results is particularly interesting because several studies have found that increases in age are associated with increases in commuting strain, such that older drivers generally report higher stress levels (Hill & Boyle, 2007). The reason for the different pattern of effects between stress and exhaustion within the current commuting process is not yet understood; hence, additional research is needed to explain this finding.

Additionally, the result showing that higher coping efforts made to deal with the commute are positively correlated with greater feelings of exhaustion can be understood within the framework of maladaptive coping strategies. Strategies such as avoiding unnecessary interaction during the commute, desiring to use another form of transportation if they can afford it, and willingness to quit one’s job or move to a job closer to home are consistent with those described as restraint coping (that is, waiting for a more appropriate opportunity to react) and mental disengagement (that is, using alternative activities to take one's mind off a problem) in the general literature (Carver, Scheier, & Weintraub, 1989). Although these coping strategies may temporarily relieve the stressful situation, they were related to more frequent feelings of exhaustion in this study and may be seen as maladaptive. Consequently, additional effort also needs to be placed on further delineating the role of coping efforts in the context of examining commuting stress among individuals. Altogether, the analytical results of research questions two and three indicate that the roles of these different psychological and systems variables discussed above, which moderate reactions to crowded commuting, should be explored further.

7.6.2 Research Question Four

The fourth objective of this thesis was to test the existence of spillover effects of crowding on both individual and work outcomes. The results of the path analysis via SEM reveal an adequate degree of fit to the data and support a refinement of the final research model. More importantly, the results confirm that stress attributed to crowding has the potential to spill over to other aspects of the commuters' life and work.

A significant spillover effect on commuters' health makes the strongest contribution to the variance explained in the final research model. In particular, commuters reporting higher levels of stress due to crowded commuting reported more somatic symptoms of ill health such as headaches, tension, stiff muscles, and sleeplessness. This is possible, as stress was among the most often reported factors found to influence general health (Yan et al., 2009). In their review, Cox and Griffiths (2005) state that the experience of stress induces a variety of psychological and physiological changes that may threaten physical health in the long run. For many commuters, such changes may contribute to health-related dysfunction and discomfort. It is also possible to interpret this finding using the explanations proposed by Fuller et al. (1993) and Cox et al. (1982), which have been discussed in Chapter 2. These researchers suggest that stress associated with crowded conditions can weaken the immune system and make a person susceptible to ill health. Additionally, close physical proximity in overcrowded conditions may increase the probability of being exposed to infectious diseases, particularly coughs and colds.

Spillover effects from passenger stress were also found for work outcomes such as lateness. This result is plausible, since passengers often let overcrowded trains pass, hoping that the next train will be less crowded. The stress involved in this decision, and in waiting for the next train (not knowing the likely length of wait, hoping it will be less crowded), can therefore be associated with lateness for work. Research by Koslowsky (2000) shows that lateness is a logical outcome of commuting-related stressors such as traffic congestion, transport breakdown, or delays in public transportation (p. 402), and this study extends those findings by demonstrating that crowded commuting can also contribute to lateness to work.

Commuters' experiences of stress were also associated with an increased propensity to be absent from work. This result is consistent with those reported by Cassidy (1992) and Costa et al. (1988), who found that increased absenteeism is correlated with stressful, crowded commuting. Alternatively, greater absenteeism from work could be an effect of health problems arising from the stressful commute. Studies reported in Chapter 2 of this thesis found positive associations between incidences of influenza or ill health complaints and crowded train journeys (for example, Gershon et al., 2005; Costa et al., 1988; Taylor & Pocock, 1972). Therefore, it is likely that the link between workplace absenteeism and stressful commuting is more subtle, as commuting to work represents yet another obstacle to overcome when an individual also suffers from physical illness (Koslowsky et al., 1995).

Past research examining the potential effect of commuting has suggested that commuting to work may impose costs on organisations in the form of higher staff turnover (Novaco et al., 1990). Although actual turnover was not examined in the present research, studies indicate that turnover intention can be a valid indicator of actual turnover, as workers typically make a conscious decision to do so before actually leaving their jobs (Mor Barak, Nissly, & Levin, 2001; Shore & Martin, 1989). In light of the passenger survey results, the spillover effect of crowding stress was found to be associated with significant increases in intention to quit among the respondents. While the limited existing literature shows that individuals who spend longer times commuting expressed a greater intention to quit (for example, Burke, 1995), this finding adds empirical support to prior research by demonstrating that turnover intention can be explained, at least in part, by understanding the role of crowded commuting.

One interpretation of this finding is that commuting on crowded trains on a daily basis may add further stress to an already stressful work or home environment, and while this situation may not necessarily lead to actual turnover behaviour, it can generate the intention to quit one's job. Furthermore, studies by Novaco et al. (2001; 1990) show that not only do individuals change their job as a method to cope with transportation stressors, some even relocate their place of residence for similar reasons. Therefore, it is important that this finding should be interpreted cautiously within this context, as studies of actual turnover suggest that the effects of commuting on individual's turnover behaviour are potentially affected by a wide variety of socioeconomic and individual factors (Koslowsky et al., 1995). Consequently, additional research is needed before firm conclusions are drawn; however, the present finding does suggest that the experience of stress arising from crowded commuting can influence employees' turnover intention.

Although studies reported earlier in Chapter 2 reveal that transport crowding is associated with both decreased job and life satisfaction (for example, Passenger Focus, 2006; Cassidy, 1992; Costa et al., 1988), such associations were not found in the present study, suggesting that there is no significant spillover effect of crowding stress on life and work satisfaction. However, this is not to say that other commuting-related variables do not affect individuals' living and working situations as previous studies have revealed that people who spend more time commuting report lower satisfaction with their life and job (Novaco & Gonzalez, 2009; Novaco et al., 1990).

More recent research also supports this finding by demonstrating that the various dimensions of the commuting situation are associated with higher stress levels as well as with increased job and residence dissatisfaction (Gottholmseder, Nowotny, Pruckner, & Theurl, 2009). However, there is also an argument that most people accept the burden of commuting because they perceive that the trade-off between long distance travel and other values, particularly monetary or material incentives, as being "worth it". Economists, who call this scenario the "commuting paradox", state that the individuals' commutes might be compensated by improvements in some other domains, such as higher pay, the ability to live in a desirable neighbourhood, a lower cost of living, affordable and better housing, or better schools for children (Stutzer & Frey, 2008). Therefore, more research is needed to consider the issue of trade-offs among commuting situations, residential and workplace locations, and stress-related health problems when examining the overall effects of commuting.

The processes underpinning spillover effects such as those described above can be explained in terms of contemporary theories of work-related stress such as the transactional model of Cox and his colleagues (Cox, 1978; Cox & Mackay, 1981; Cox & Griffiths, 2005; Cox & Griffiths, 2010). This theory depicts stress as a process centred on three important aspects: (1) sources or antecedent factors, (2) cognitive perceptual processes that contribute to the emotional experience of stress, and (3) correlates of that experience (Cox & Griffiths, 2005). A similar approach can be employed in the current context whereby rail environments that are perceived as psychologically crowded may trigger negative cognitive appraisals that lead to specific emotional experiences of stress, including spillover effects.

Alternatively, another explanation could be offered in terms of crowding being a form of impedance which hinders commuting. Studies by Novaco et al. (2001; 1991; 1990), which focus on the inter-domain transfer effects of travel impedance, argue that traffic congestion can constrain passengers' movement and goal attainment and thus lead to stress and frustration. They suggest that the transfer of such effects across different life domains may follow the "excitation transfer" theory, whereby arousal occurring in one domain can transfer to another. This type of explanation might be applied to the effects of passenger crowding.

In summary, the analyses of the results have supported and refined the fourth objective of this thesis. These findings, in particular, strengthen our current understanding of the nature and effects of passenger crowding.

7.6.3 Research Question Five

The final objective of this study was to identify potential interventions that might resolve issues associated with rail passenger crowding. It has also evaluated whether these measures correspond to interventions proposed by Cox et al. (2006), who posit that many of the crowding-related problems can be effectively mitigated by considering the role of moderating factors in the density–crowding relationship, and that psychologically oriented interventions can have great potentials for applications within the current rail environment. Based on the results drawn from the free-text responses in the questionnaire, the Cox et al.'s model developed further in this thesis allows for a variety of interventions that may attenuate both the direct effects of crowding and any spillover effects.

Most obvious among the interventions that have been suggested is improving the quality of the ambient environment of the crowded situation. Some of the measures that are consistent with Cox et al.'s (2006) model from this aspect include redesigning the seats and coaches to allow for ample head and legroom. This approach to intervention might provide a greater personal space and better ventilation that passengers require (Evans & Wener, 2007; Cox et al., 2006). Alongside this, addressing the psychosocial environment as reflected in passengers' evaluation of crowdedness should also help. Potential interventions identified in the present study echoed those found in Cox et al.'s studies (2006; 2003) and consisted of measures like providing accurate and timely information about the availability and schedule of the rail services, or educating passengers to better plan for and cope with their rail journeys. Such measures can benefit the passengers by providing greater predictability of the commute and a better degree of control that they are able to exercise while travelling on crowded trains.

In addition, offering some forms of on-train entertainment could also provide practical support to cope with the crowded commute. According to several respondents, not only can this measure reduce the stress of commuting, it can also be used by the rail operators to facilitate real-time communication for passengers. To some extent, all these results reaffirm the potential effectiveness of crowding mitigation initiatives targeted at moderators of the relationship between high density and the perception of crowdedness, as first suggested by Cox et al. (2006). Therefore, even if engineering or systems solutions are not easily to hand or affordable, there is still much that can be done, driven by research such as that reported here.

Of course, reducing the direct effects of crowding by means of engineering interventions could also serve to prevent any spillover effects. The importance of this approach in mitigating crowding-related problems on the rail network is apparent in a number of suggestions made by all respondents. As reflected from the analysis, measures such as adding extra capacity, providing regular maintenance of rail infrastructure and train carriages, enforcing effective systems for scheduling and timetabling operations, and introducing new technologies were suggested. This result is not surprising because much of the literature relating to the UK, Malaysia, and elsewhere often report that the engineering perspective tends to inform most transport strategy developments (see for example, Performance Management and Delivery Unit (PEMANDU), 2010; London Assembly Transport Committee, 2009a; Wener & Evans, 2004; House of Commons Transport Committee, 2003). This is particularly so within the Malaysian setting, where long-standing transportation woes including unclear transport policy, insufficient forward planning, and adversarial relationships between rail (and other transport) providers contribute to the poor performance of public transport services (Ahmad, 2010; Zakaria, 2003; Pacific Consultants International & Suuri-Keikaku Co. Ltd, 1999). It follows that the majority of respondents view these deficiencies in the rail industry as taking a more important role in solving the country's public transport problems. It is therefore understandable why commuters place more emphasis on engineering interventions rather than psychosocial interventions in the improvement of the public transport system.

7.7 Chapter summary and conclusions

This chapter has reported a study which explores the relationships among the different psychological components of crowding and their direct and spillover effects on commuters. More specifically, it has presented the results of statistical tests performed on the data to answer the research questions developed at the initial stages of the research programme. While the first research question addresses the development of an instrument to gauge the experience of crowding (Chapter 6), the second research question focuses on exploring the extent of the relationships among the psychological components of crowding and passenger density on stress and feelings of exhaustion. Results of path analysis showed that the evaluation of the psychosocial aspects of the crowded situation and of its ambient environment as well as rating of passenger density can lead to more negative affective reactions to crowding among commuters. The negative impact of these reactions can, in turn, lead to greater passenger stress and feelings of exhaustion. Commuters' evaluation of the psychosocial aspects of the crowded situation and of its ambient environment as well as their ratings of passenger density did not directly predict stress and feelings of exhaustion.

The third research question asks how well stress and feelings of exhaustion can be predicted by the crowding experience and rated passenger density. The hierarchical multiple regression results showed that crowding has a significant effect on the experience of stress, but not feelings of exhaustion after controlling for demographic and individual differences in commuting experience variables.

The fourth research question extends the second and third research questions by testing the existence of spillover effects of crowding on both individual and work outcomes. An overall final model was proposed together with two specific hypotheses. The final model yielded an acceptable degree of fit to the data and the results of the analysis supported and refined these hypotheses. The results confirmed that passenger stress, attributed to crowding, has the potential to spill over to other aspects of the commuters' life and work in terms of propensity for lateness and absenteeism for work, intention to quit, and somatic symptoms of ill health.

The last research question sought to identify potential initiatives aimed at mitigating the effects of rail passenger crowding. The results derived from the free-text responses to the questionnaire showed that passengers place capacity enhancement and frequent and punctual services high on the list of recommended interventions. The results also provide some insights into other potential measures that are consistent with Cox et al.'s (2006) model. These measures include regular maintenance of all rail infrastructures, improved information provision, redesign of the train carriages, and installation of passenger detection systems. It appears that while an engineering perspective on crowding mitigation still remains prominent in interventions suggested by the commuters, psychologically oriented interventions are also viewed as effective and beneficial in mitigating crowding.

Taken together, these analyses showed that all research aims were achieved in that a final model depicting the relationships among the psychological components of crowding and their direct and spillover effects on both individual and work outcomes was developed and empirically validated. Having presented the results, the following chapter provides an overall discussion of the significant results obtained in both Phase One and Phase Two of the research and elaborates on the implications of these findings.

CHAPTER 8 – GENERAL DISCUSSION, IMPLICATIONS, AND FUTURE RESEARCH

8.1 Chapter overview

The chapter begins by summarising the research findings (Section 8.2), which are based around the research questions and the operational model outlined in Chapter 3. It then proceeds by discussing the implications of these findings for theory, measurement, method, practice, and policy in Sections 8.3 to Section 8.7. The chapter concludes by reflecting on important theoretical and methodological issues and discussing the possibilities for future research that would extend the work of this thesis (Section 8.8 and Section 8.9).

8.2 Summary of research findings

The main objectives of the present research were to examine how and to what extent a relationship exists among the different psychological components of crowding, passenger density, experience of stress, feelings of exhaustion, and the subsequent spillover effects. To begin to address these objectives, a systematic review was performed. As documented in Chapter 2, the review identified four significant gaps within the rail literature. First, where crowding has been explored, researchers have tended to focus on its direct effects and less on its potential spillover effects. Second, while the spillover effects of tangible commuting factors, such as distance and duration of the journey have been studied, the role of passenger crowding has been largely ignored as a potential source of commuter stress. Third, researchers differ in their views on the definition and construct of crowding as well as on its measurement attributes. Fourth, there is a pressing need to pursue methodologically sound theoretical explanations that go beyond conventional density measurement so that the effects of crowding can be fully examined. Thus, these gaps in the literature warrant further empirical and analytical assessment of the potential relationships between the different psychological components of crowding and their direct and spillover effects.

Further to this, it was felt that more attention is needed to explore which theoretical frameworks provide a useful orientation for this research work. Previous research (discussed in detail in Chapter 3) has demonstrated that there are a variety of classical and integrative approaches in which rail passenger crowding can be investigated. These different approaches have been evaluated with the purpose of formulating the appropriate frameworks to investigate this issue. Of these approaches, the Cox et al.'s (2006) model of crowding, stress, health, and safety was selected as the basis for modelling the relationships which underpin the direct and spillover effects of rail passenger crowding (see Figure 8.1).

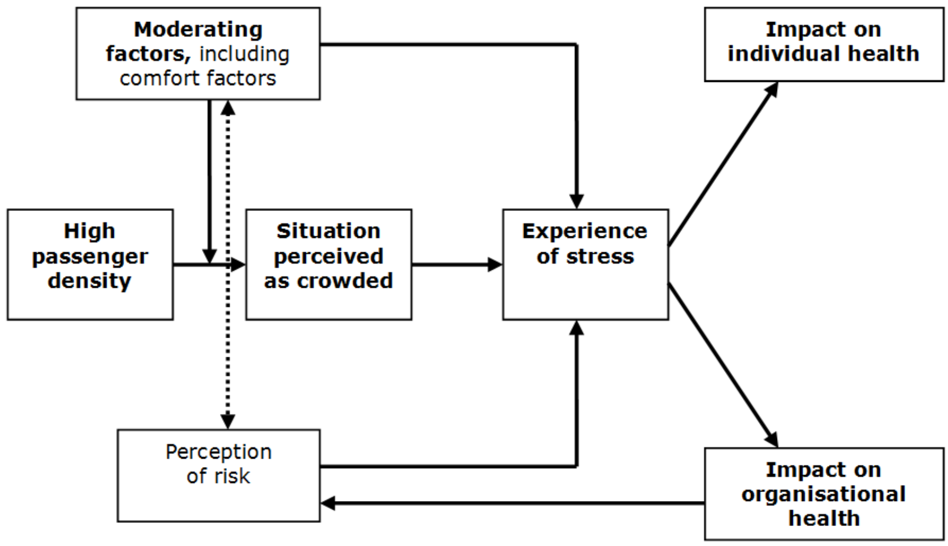

Figure 8.1. Cox et al.'s (2006) model

A model that permits the operationalisation and refinement of the variables specified within Cox et al.'s original model was then proposed (see Figure 8.2).

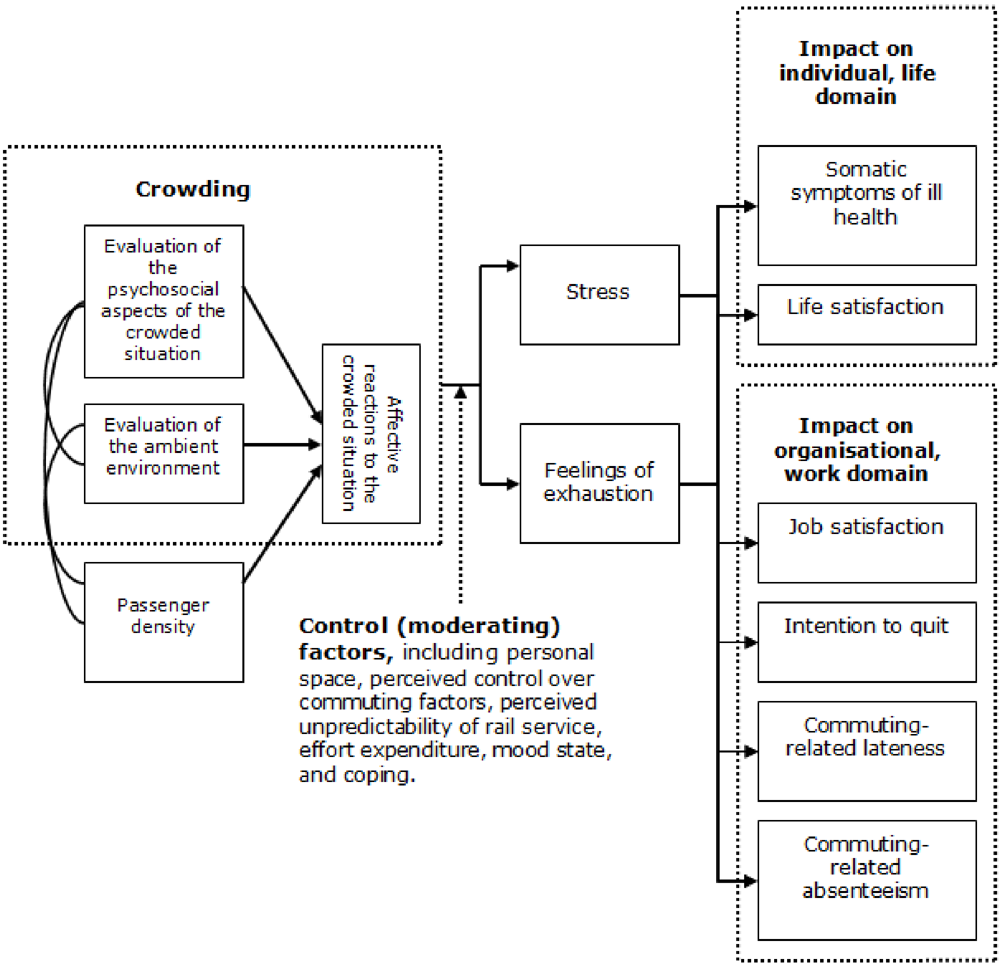

Figure 8.2. Operational model of the nature and effects of rail passenger crowding tested in this thesis.

This operational model refines Cox et al.'s (2006) model in four ways. First, it conceptualises the experience of crowding as a multidimensional construct comprising three components: (1) the evaluation of the psychosocial aspects of the crowded situation, (2) the evaluation of its ambient environment, and (3) affective reactions to crowded situation, alongside passenger density. In doing so, the model refines the original model and makes concrete the different psychological dimensions of crowding. Second, six moderator variables identified from the literature were included and operationalised in the present model. Third, a more comprehensive perspective on the effects of rail passenger crowding was adopted by incorporating a measurement of sub-optimum health status together with the experience of stress measurement as direct outcome variables. Finally, the spillover effects on both individual and organisational domains were operationalised using six outcome variables. Altogether, the discussion in Chapter 3 justified the necessity of an integrated theoretical framework and made a case for the refinement of Cox et al.'s model and how it is integrated within this thesis.

To firmly establish the extent of the effects of crowding on rail passengers and to test the existence of its spillover effects on both individual and work outcomes, five research questions and eleven hypotheses were developed and investigated through questionnaire surveys with key stakeholders (Chapter 5) and commuters (Chapters 6 and 7). These research questions and hypotheses are discussed in Section 3.5 of Chapter 3.

Data on ridership growth and passenger loading for each rail line surveyed obtained from the key stakeholder scoping survey (Phase One) indicated that passenger crowding is a significant issue for Kuala Lumpur's rail services and provided support for the selection of Kuala Lumpur as the location to conduct field research for this thesis. Despite these data, this issue was generally perceived to be a common problem by the majority of the key stakeholders compared to capacity, infrastructure, and service quality issues. In addition, neither statutory control to determine a safe crowding level on trains nor any form of benchmarking process to evaluate the performance of rail passenger services is currently in existence in Malaysia. The lack of priority placed on passenger crowding by key stakeholders was further reinforced by a strong sense that any crowding-related problems would be addressed by focusing on issues such as capacity enhancement, infrastructure development, reliability and performance improvement, strategic planning, and regulatory enforcement. An interpretation of the findings of this study, however, is limited to key governmental, non-governmental, and industry stakeholders.

In Phase Two, the use of a cross-sectional questionnaire survey of rail commuters in Kuala Lumpur allowed a more rigorous interpretation of the findings. Not only did the findings of this phase extend the empirical relevance of the first study, they also provided answers to the five research questions of the thesis outlined in Chapter 3. First, the present study supports a multidimensional model of crowding experience comprising three different psychological components. In particular, the results demonstrate the relationships among passengers' evaluation of the psychosocial aspects of the crowded situation and of its ambient environment, their affective reactions to it, and the relationships among these psychological components of crowding and passenger density.

Second, the results suggest that the three measures of crowding experience together with rated passenger density are combinatorially predictive of commuters' stress and feelings of exhaustion. It was also found that high passenger density per se seems not to be a direct source of psychological stress or feelings of exhaustion for commuters. This result thus shows, among other things, the imperfect relationship between the more psychological components of crowding and passenger density.

Third, the results revealed further that the effects of the experience of crowding and passenger density on commuters' feelings of exhaustion disappear when controlled for multiple factors, including demographic and individual differences in commuting experience. However, their effects on the experience of stress remain significant even after controlling for similar factors.

Fourth, different patterns of spillover effects for passenger stress were revealed. More specifically, passenger stress spills over to other aspects of the commuters' life and work in terms of propensity for lateness and absenteeism at work, intention to quit, and somatic symptoms of ill health, but not in terms of their job or life satisfaction.

Based on these results, the operational model specified earlier in the thesis was revised, yielding a final model that is both theoretically meaningful and statistically well-fitting in providing an adequate explanation of the observed data (see Figure 8.3). The final model differs slightly from the earlier operational model in two ways. First, "feelings of exhaustion" was dropped from the model because the results of the hierarchical regression analyses did not support the significance of the experience of crowding and passenger density as predictors of exhaustion when controlled for demographic and individual commuting experience variables. Second, the model removed life and job satisfaction as spillover effects following the analyses described in Chapter 7. Nonetheless, the findings from both studies reinforce the assertion that crowding poses a possible threat to the health of both organisations and passengers, as first proposed in Cox et al.'s (2006) model.

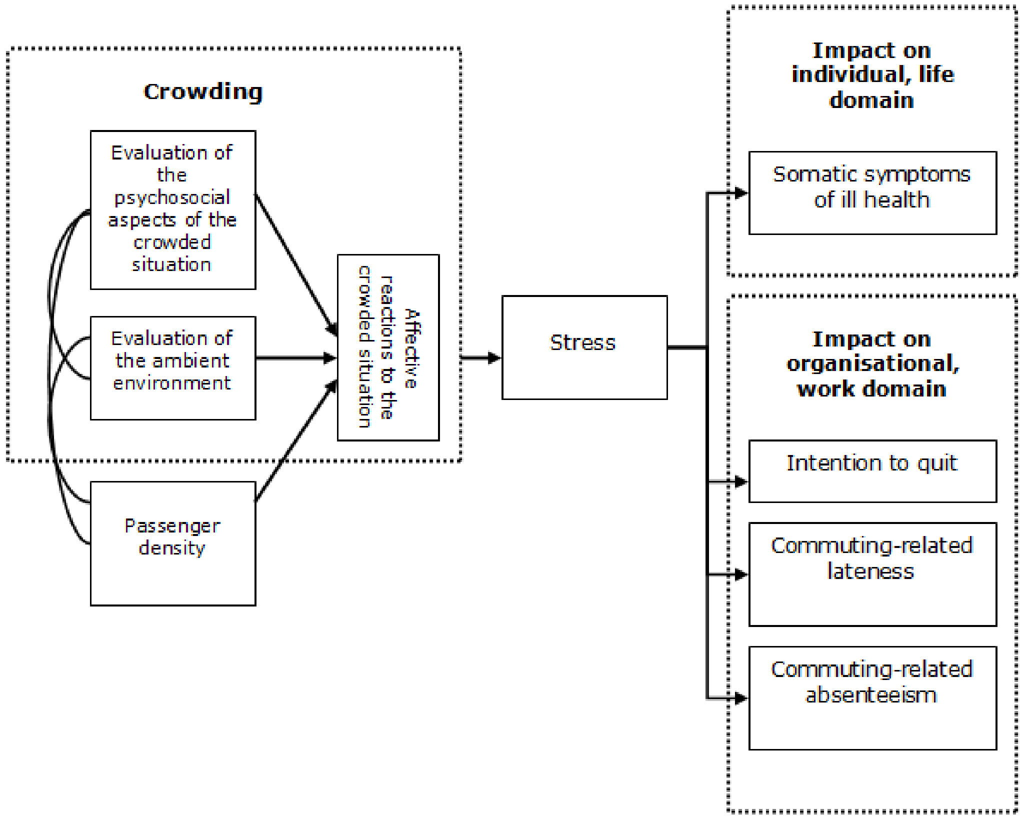

Figure 8.3. Final model of the nature and effects of rail passenger crowding showing direct and spillover effects.

Finally, the analysis of the written responses to both surveys shows that all respondents proposed initiatives which have many features in common with Cox et al.'s model, although with a slightly different emphasis. While governmental authorities, rail operators, and non-governmental organisations tended to pay more attention to governance, policy, engineering, and economic-based interventions, commuters suggested a wider range of intervention strategies that encompasses both engineering and psychological solutions. Some examples of the psychological interventions suggested by commuters include improving information provision, offering on-train entertainment, redesigning train carriages, and allocating specific coaches for women, the elderly, and disabled passengers.

Having summarised the research findings, these results are discussed in relation to both their theoretical and measurement implications in the next section. Methodological implications alongside practical and policy implications arising from the present work are also elaborated upon.

8.3 Theoretical implications

As described in Section 3.4 of Chapter 3, Cox et al.'s (2006) model of crowding, stress, health, and safety served as the general framework for the present work. To recapitulate, the model proposes that crowding may drive the experience of stress and consequently may generate spillover effects on both individual and work life. More importantly, the model suggests several interesting theoretical predictions in the context of limited available evidence at that particular time. This model (together with the reviews in Chapters 2 and 3) provides a broad overview of the potential patterns of relationships between antecedents, mechanisms, and outcomes of crowding; suggests what variables ought to be measured, estimated, and controlled in rail passenger crowding research; and helps to form the basis on which the research questions were developed.

A potential concern about this model, however, is that while it provides a sensible framework for the explanation of rail passenger crowding, its empirical support is not well established. In particular, the model is constrained by a lack of empirical data to validate its use as a tool for understanding passengers' crowding experiences and their possible direct and spillover effects. Furthermore, some of the variables in the model are not clearly operationalised. For example, the interplay of cognitive, social, and environmental factors in producing crowding experience is not explicitly depicted in the model. Therefore, in its present state, the model does not readily lend itself to practical testing. Nevertheless, despite these acknowledged limitations, the model provided a suitable theoretical framework for the present research.

For the above-mentioned reasons, the studies described in this thesis attempted to provide the necessary empirical data to test and develop the model. These aims were addressed in three successive stages: (1) the relationships among the different psychological components of crowding and passenger density in relation to passengers' experience of stress and feelings of exhaustion were tested, (2) the potential influences of demographic (gender, age) and commuting experience variables (personal space, perceived control, commute unpredictability, mood state, effort expenditure, and coping) on crowding and its direct outcomes were considered, and (3) the contribution of the full model with respect to individual and work domains was evaluated.

The finding that there is an interplay among the different psychological components of crowding provides some support for Cox et al.'s theoretical assertion that individuals' crowding experience involves cognitive, social, and environmental factors. Therefore, in a consideration of the effects of crowding, it is essential to take into account the potential roles of these psychological components. Additionally, evidence associating the links between crowding and psychological stress, physical health, and organisational behaviours are supported by the present work. Therefore, this research demonstrates the empirical utility of Cox et al.'s model in understanding the nature and effects of rail passenger crowding.

Cox and his colleagues (2006) also emphasise the need for more research examining the relationships between satisfaction with work and domestic life and crowding and stress effects (p. 252). The present study addressed this need. However, evidence in favour of this relationship remains limited. The findings within the individual and organisational domains do not support this claim, as evidenced by the non-significant results between crowding stress spillover on life and job satisfaction. This inconsistent finding may be attributed to the fact that the interaction between crowding stress and life and job satisfaction is too simplistic to capture the complex dynamics among these variables. Therefore, further studies are essential to elucidate this interaction.

The model proposed in this thesis also considers the contribution of physical, social, and psychological explanations of crowding (discussed in Chapter 3). For instance, since the density-intensity theory (Freedman, 1975) argues that crowding is a physical phenomenon, the passenger density measure adopted from RSSB (2004) was embodied in the current model. However, viewing crowding simply as a physical phenomenon does not always work (Stokols, 1972a; 1972b). The reverse argument is also true for socially and psychologically driven explanations of crowding; that is, if we only consider crowding as either a social or psychological phenomenon, the construct cannot be adequately explained without taking into account the role of physical density. Realising that using the classical explanations of crowding on their own does not explain the entire picture of the phenomenon, the physical, social, and psychological aspects of crowding were integrated in the current model and the relationships between them explored.

In summary, at the level it is pitched, the new model developed and tested in this thesis lends empirical support to the Cox et al.'s model by adding more information about the nature and effects of rail passenger crowding and providing more confidence in the adequacy and utility of the original model. Although the current model does not replace or challenge established frameworks suggested in the existing crowding models (both classical and integrative), it provides an interesting complementary view for understanding and explaining this phenomenon.

8.4 Measurement implications

Three measurement implications arise from the research findings. First, the reviews of theories and measurements in Chapters 2, 3, and 6 highlight the different approaches available to conceptualise the experience of crowding, and it is apparent that these different theories tend to give rise to different types of measurement. For example, some emphasise the simple estimation of physical density (for example, RSSB, 2004; Freedman, 1975), while others focus on the importance of psychological or social factors for the measurement of crowding (for example, Stokols, 1972b). These singular approaches are all relevant, but it is again argued that taking one approach alone does not reveal enough to completely understand or quantify the individual's crowding experience.

Our data from modelling using the SEM technique discussed in Chapter 6 suggest that a multidimensional measurement of crowding is needed in order to adequately describe the whole picture. The instrument developed in this thesis to some extent provides an alternative lens through which crowding may be viewed and understood. The findings suggest that individuals' crowding experience is an essentially subjective, psychological phenomenon and is better represented as a multidimensional construct rather than as a single, unidimensional experience. However, being multidimensional about the experience of crowding is not about adding up the different components and obtaining a grand total score of the magnitude of crowding experience. Rather, it is about explicitly recognising that there are important components of crowding that cannot be adequately represented by a single global rating or score. For a more accurate measurement and conceptualisation of the crowding experience, it is therefore recommended that future studies should use this instrument (or something similar to it) in order to better understand this phenomenon.

Second, the findings offer an opportunity to challenge the prevailing passenger density and loading measures used in the rail industry. Up until recently, the literature dealing with crowding in this setting predominantly focuses on passenger density, and the pathways that may link the subjective aspect of crowding with outcomes have not been fully explored. The findings discussed in Chapters 6 and 7 of the present work to some extent challenge this norm and make the case for the role and significance of the psychological components in assessing crowding experiences among passengers. In particular, the present work provides findings that empirically delineate the three components of crowding experience and addresses the assertion of researchers such as Cox et al. (2006) and Turner et al. (2004) that rail-related studies need to provide a better conceptualisation of this construct.

Finally, the present work advances knowledge in this area as it offers a prospective working model that allows for further research into issues concerning the perceptions of and reactions to crowding. It looks beyond the classical approach of crowding stress to an integrative framework and expands the scope of inquiry by incorporating the Cox et al.'s (2006) model of passenger crowding, stress, health, and safety into its operational model. The refined model provides new empirical and theoretical foundations and is appropriate to help explain the direct and possible spillover effects of crowding. Although causal inferences could not be drawn from the current work, there is sufficient evidence to challenge us to continue research in this area, to develop plausible theoretical explanations of our findings, and to apply them in managing the challenge of passenger crowding.

8.5 Methodological implications

At a methodological level, the present work suggests that eclectic or multi-method research designs used to investigate the experience of crowding and its associated outcomes may also be successfully applied to other research settings, including other public transport modes, residential, marketing, and tourism. As discussed in Chapter 4, multi-method studies have become popular, especially in the context of health and safety issues within the rail environment. The eclectic design used in this thesis captures a broad base of information from the respondents and, as such, is regarded as fit for purpose and appropriate for an examination of the issues involving different stakeholders, types of data, and analyses.

In addition, the SEM approach used to uncover the relationship patterns among the variables reported in this thesis may prove to be a useful tool in the study of crowding in general. It could, for example, be used to help researchers test and validate the theoretical models they propose. Furthermore, the assumptions embodied in SEM models to some extent allow the identification of potential causal relationships between crowding and its associated outcomes. Researchers such as Pearl (2010) argues that "establishing causation", which requires careful manipulative experiments, is different from "interpreting parameters as causal effects", which may be based on firm scientific knowledge or on previously conducted experiments (p. 1). Substantiating this proposition through a series of mathematical solutions, he shows that SEM possesses both theoretical and mathematical properties for processing knowledge, combining it with data, and drawing new causal conclusions about a phenomenon. Nonetheless, this is not to say that this thesis presumes a causal relationship between crowding, stress, and the associated spillover effects. Yet the results of this present work do suggest possible directions for further research.

8.6 Practical implications

From a practical point of view, several implications emerge. The findings that the different psychological components of the experience of crowding are positively related to passenger stress and spillover effects, highlighted in Chapter 7, need to be recognised and acted upon by the appropriate authorities. Indeed, crowding is not only an issue of comfort, but also an issue of health and safety for a great majority of passengers. This recognition is important in Malaysia, particularly where the key stakeholders' overall attention to passenger crowding is still relatively low (as revealed in Chapter 5). In view of the results of the current research, a case could be made for urging rail-related authorities to start taking greater account of psychological effects, health and safety concerns, and the comfort needs of the passengers. Given this, identifying and controlling the physical and social antecedents of crowding stress experienced by the passengers should be a primary agenda for all rail operators. This can be achieved in at least three ways.

The first concerns the role of effective communication in rail services. Through improved passenger information systems and better communication technology, the physical and social antecedents of the experience of crowding can be managed to minimise negative consequences for passengers. As Cox et al. (2006; 2003) assert, timely and accurate information on rail services could help passengers reshape and redefine their expectations of rail travel and could perhaps also change their attitudes to crowding. Suggestions received through the passenger survey (Chapter 7) also resonate with this theme. Some specific examples of types of information that are considered helpful, as suggested by the respondents, include crowding levels on trains and at stations, delays and cancellations, nature and causes of service disruptions, and availability of the next train. Along these lines too, several respondents suggested that providing accurate and visible signage would improve passengers' wayfinding information needs as well as be effective in generating a better commuting experience for them.

As highlighted in Section 5.5.5 of Chapter 5, promoting public awareness as a means of facilitating travel choices is being considered by the key stakeholders in addressing train capacity and passenger crowding issues. Although the plan is still in its early stages, it is starting to head in the right direction. Studies by Cox et al. (2006; 2003) indeed suggest that an appropriate level of crowding can be maintained by educating passengers to better plan for and cope with their rail journeys. This idea is further supported by a recent study by Henn et al. (2010), who found that public awareness and educational campaigns that encourage commuters to move their travel to less congested times have a strong potential to shift behaviour as well as make people aware of crowding conditions, thereby reducing demand during peak periods.

On the basis of the findings from the key stakeholder survey (discussed in Chapter 5), it is quite understandable that the costs of procuring additional rolling stock and constructing new infrastructure and facilities needed to meet peak passenger demand have become more immediate concerns among the key stakeholders. Beyond the issue of cost and infrastructure, however, lies a more practical solution in addressing capacity constraints. For instance, rail operators can help mitigate crowding-related stress by the creative and operational design of the rail infrastructure, particularly by focusing attention on the interior functionality of a train. The environmental psychology and ergonomics literature offers many theoretical insights into the fundamental design principles that are shown to alleviate crowding and its consequences (Bell et al., 2001). Floor plan, seating orientation, spatial layout, colour schemes, physical separators, territorial props, lighting, ventilation, and visual distractors are only a few of such examples.

In addition to interventions that influence the experience of crowding, the third form of intervention focuses on the practical management of crowd dynamics. During the second phase of the current research, several respondents suggested that possible engineering solutions (for example, a detection system that will limit the number of passengers in each train carriage) and human solutions (for example, physical presence of specialised staff on platforms and carriages) would somehow improve crowd management. While these suggestions are not exhaustive or definitive, they do offer rail operators several valuable ideas for facilitating crowd monitoring and crowd control. Some specific examples that may be of interest include: (1) installing an alarm system or other warning signal for the detection of overcrowding on the train, (2) allocating ushering and security personnel to disperse crowds, (3) enhancing passenger flow mechanisms which facilitate access to and egress from crowded trains, and (4) introducing an efficient, reliable, user-friendly, and integrated ticketing system to control the crowd flow.

8.7 Policy implications

Studies such as the current one may also provide some empirical evidence to serve as the foundation for policy making and planning. The foremost concern is the need to establish a judicious loading policy which not only restricts passenger loading levels to within the current capacity of the rail system but also requires the rail operators to enforce adequate measures to reduce overcrowding and to improve punctuality and reliability targets. In addition, such policy initiatives should include procedures for implementing good practice approaches to crowd management and crowd monitoring on the railways as well as specify appropriate penalties for non-compliance.

A further implication for policy planning is the potential of peak demand management as a means of relieving passenger crowding. Peak demand management, in the rail passenger context, refers to the collection of operational, administrative, and economic policies designed to ensure that demand for the utilisation of (rail) transportation resources is kept at a manageable level, especially during peak commuting periods (Henn et al., 2010). A number of strategies are proposed throughout the literature to identify viable solutions for this issue, including trip suppression, trip redistribution, shifting demand, mode switch, and peak fare pricing (Henn et al., 2010). Of particular interest is the use of programmes that offer commuters resources and incentives to reduce their commuting trips. For example, studies on alternative work schedules show that a compressed workweek, flexitime, staggered shifts, and telecommuting can all decrease the time spent commuting, reduce peak period congestion, and facilitate employee ridesharing and transit use (TDM Encyclopedia, 2010). A similar approach could be promoted in this respect and in fact is already underway in Malaysia, with some organisations already offering telework arrangements for their employees (Hamsa & Wan Mohd Rani, 2009).

8.8 Reflections on theoretical and methodological issues and suggestions for future research

Although this research contributes to the growing body of literature on crowding stress, a number of issues warrant research attention in the future. One of these involves the examination of the criterion validity of the crowding experience instrument developed in this thesis. In the present research, only convergent, divergent, and construct validity were assessed, and it is not yet clear whether this instrument will correlate well with other existing crowding measures. Furthermore, it remains uncertain whether the characterisation of its factor structure would hold for all crowding conditions. Therefore, additional validation of the instrument is recommended. One possible enhancement that could be useful to clarify the extent of the instrument's utility is to compare it with other crowding measures to further assess its criterion-related validity.

In addition, as the study is cross-sectional, where respondents' crowding experiences were reported at a particular point of time, it is possible that the respondents' perception might change over time. Such issues may, in turn, affect the validity of the present instrument. Accordingly, it would be interesting to further evaluate its full potential in assessing the experience of crowding and forecasting its various outcomes by testing it using a wider variety of research settings and study population. In doing so, additional normative information concerning the instrument's psychometric properties could be established.

Two other methodological issues arising from the present work are causal interpretation and method variance. First, the research offers only a correlational interpretation of its findings, thus the influence of a host of other variables such as personality, culture, adaptation to crowding, and crowd dynamics on crowding stress and spillover effects cannot be ruled out. Therefore, the use of a longitudinal and experimental design could offer more conclusive evidence in regard to the accuracy of these associations. For instance, simulating a rail passenger-crowding scenario in a series of experimental studies could establish the causal mechanism of crowding while maintaining control over the conditions. Alternatively, conducting longitudinal studies would allow a more rigorous interpretation of the results. By collecting data on passenger crowding and its associated effects at two or more different times, we can reasonably determine whether variation in the experience of crowding precedes variation in the outcomes. In doing so, this design would serve to strengthen the argument that the experience of crowding plays a causal role in relation to changes in psychological stress and other associated spillover effects.

Second, all measures used in the two studies were primarily based on self-reports, thus raising concern about the potential issue of common method variance. However, as discussed in Chapter 4, several procedural methods were followed, including keeping the questionnaires clear and relatively easy to answer, assuring the confidentiality of the data, and reducing the respondents' evaluation apprehension. These measures may to some extent overcome the problem associated with common method variance. Nonetheless, we acknowledge that the use of objective or independent measures would further strengthen the present work. For instance, salivary cortisol has been used as a biomarker of psychological stress among commuters in several studies such as those by Evans and Wener (2007) and Wener et al. (2005). Therefore, it is desirable that prospective studies in this area consider the use of salivary cortisol or other physiological measures of stress so that the co-variability between both subjective and objective measures can be compared. Additionally, the use of independent measures such as organisational records of sickness absence and turnover can also supplement subjective measures and enhance the interpretation of the findings (Razavi, 2001).

Since the final research model generated from the path analysis was produced using an exploratory approach, research is also needed to refine this hypothetical model. For instance, the current model argues that certain aspects in the rail environment can contribute to the perception of crowding, which, in turn, can lead to a number of adverse reactions. It is possible that some passengers are better able to cope with and manage the stress of crowding and exposure to high density. In this regard, researchers have found that personal space requirements and personality traits appear to play some roles in stress and coping processes (Evans & Wener, 2007; Sundstrom, 1978; Miller & Nardini, 1977). It is possible that individuals who have small personal space zones, or with an internal locus of control, or with a high need for affiliation may tolerate crowding stress better than those with a quite opposite pattern, involving a large personal space zone requirement, an external locus of control, or a low need for affiliation.

Apart from stress, another area that may potentially benefit from an improved understanding of crowding includes studies of cultural differences and susceptibility to crowding. Past research has confirmed that Malaysia represents a collectivist culture (Tafarodi, Lang, & Smith, 1999; Bochner, 1994; Burns & Brady, 1992), hence it is anticipated that the respondents’ experiences of crowding would be consistent with the collectivist cultural orientation (that is, more tolerant of crowding). As pointed out in the systematic review (Chapter 2), although it is an appealing assumption that there will be cultural differences, the literature existing at present does not seem to provide enough evidence to be able to pick out cultural differences systematically as a factor for the experience of crowding within the rail setting.

In terms of the present research, most of the participants were Malay and the small number of Chinese and Indian respondents does not permit a comparison between ethnicities and cultures. As mentioned earlier in Chapter 2, it is not the object of the present work to investigate cultural differences in detail; however, two observations that may be of interest can be made. First, in general, the patterns of interrelationships among measured variables do not seem to reveal any obvious differences between this research, which is based in Malaysia, and that reported elsewhere in the world. This finding implies that crowding may inflict individuals negatively regardless of culture. Second, where there may be cultural questions about the personal management of contact in crowded spaces, it is argued that crowded commuting represents a practical situation that has to be tolerated by anyone everywhere; otherwise individuals cannot use the rail systems or any other public transportation at all. This observation suggests that compromise decisions are made by all commuters, who routinely tolerate crowded conditions on trains simply because commuting has become a necessity for them.

Finally, while the sample in this passenger survey study was representative of those workers who frequently commute to work using either the LRT or commuter rail services, the same findings obtained may not hold true for moderate or occasional rail users, who have much less experience of stress associated with rail crowding. Therefore, one should exercise caution not to generalise the present results beyond the specific population used or the specific variables employed, at least until further research explores similar phenomena in other research contexts.

8.9 Conclusions

This thesis has provided support for anecdotal and empirical evidence that crowding involves different psychological components and inherently has adverse psychological consequences, including spillover effects. In doing so, the thesis contributes to the existing body of research by demonstrating that the boundaries between the commuting, work, and life domains are indeed permeable. Furthermore, this thesis has presented evidence to challenge the existing theory about density effects on stress. While a majority of researchers look for links between passenger density or train capacity and outcomes, this thesis presented evidence suggesting that the different psychological constructs of the crowding experience are central in affecting an individual's stress response. In this regard, this thesis has demonstrated the use of the multi-dimensional model of crowding in understanding its nature and effects within the context of travel and commuting.

Additionally, the thesis contributes to the crowding and transport studies and helps to bridge the gaps between the commuting, transportation, and environmental and applied psychology literature. In particular, it offers some interesting perspectives on commuters' experience of crowding stress and has additional implications for the understanding of general commuting patterns and travel behaviour in Kuala Lumpur. While there are many people still opting to drive to work, recent developments in Malaysia have shown that efforts are being made to encourage people to use public transport and other alternative means (for example, Suruhanjaya Pengangkutan Awam Darat Bill, 2010; Land Public Transport Bill, 2010). Given the current socio-economic conditions, together with these recent developments, it would not be entirely surprising if more people start using public transportation in the future. An improved understanding of the relationship between crowded commuting and its associated outcomes thus helps to formulate the framework for crowding stress mitigation as well as enhances overall transportation management and operation.

The model developed in this thesis has its theoretical foundation in an integrative framework of the human response to crowding and was empirically tested, and it was generally found to support the research hypotheses. Continuing this tradition, future research in this area must attempt to consolidate theoretical and analytical approaches to move forward toward useful and practical developments. Rigorous evaluation of the refined frameworks, along with better explanatory and predictive research, should clarify the underlying processes underpinning rail passenger crowding and allow for better management of this challenge. It is intended that this thesis will provide useful information for in-depth understanding of the antecedents, mechanisms, and outcomes of rail passenger crowding. A further hope is that the research here has served to interest and inform the readers and laid a solid basis for developing this important area further.

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RELEVANT WEBSITES

Government Transformation Programme: Urban Public Transport (UPT) lab: http://www.pemandu.gov.my/gtp/?page_id=39

Keretapi Tanah Melayu Bhd (KTMB): http://www.ktmb.com.my/

KTM Komuter: http://www.ktmkomuter.com.my/

Land Public Transport Commission (LPTC) or Suruhanjaya Pengangkutan Awam Darat (SPAD): http://www.spad.gov.my/

Rangkaian Pengangkutan Integrasi Deras (RapidKL): http://www.myrapid.com.my/

Syarikat Prasarana Negara Bhd (SPNB):
http://www.prasarana.com.my/assets/kelana.html
http://www.prasarana.com.my/assets/ampang.html

The Association for the Improvement of Mass Transit (TRANSIT): http://transitmy.org/

APPENDIX A - DATABASES AND SEARCH ENGINES SEARCHED

Category	Title	Description
Databases	The Cochrane Reviews http://www.cochrane.org/reviews/	Offers free access to summaries of all Cochrane systematic reviews of healthcare interventions.
	PsycARTICLES http://psycnet.apa.org/	Full-text database of journals published by APA and other publishers in applied psychology, health, theory, research, social, and personality.
	ScienceDirect: Elsevier http://www.sciencedirect.com/	Covers science, technology, and medicine full-text and bibliographic information, online e-books, reference works, handbooks, and book series.
	EBSCO HOST (Business Source Premier, MEDLINE, CINAHL, Pre-CINAHL, SportDiscus) http://www.ebscohost.com/	Covers reference databases, subscription managements, online journals, books, linking services, and A-to-Z solutions.
	Wiley InterScience http://www3.interscience.wiley.com/cgi-bin/home	Covers journals, books, reference works, databases, laboratory manuals, and the Cochrane Library.
	Emerald http://www.emeraldinsight.com/Insight/menuNavigation.do?hdAction=InsightHome	Peer-reviewed management journals and online support in the fields of management, library services, and engineering.
Reports and discussion papers	British Library Public Catalogue http://blpc.bl.uk/	Covers books, journals and newspaper titles, patents, and other resources in the British Library's collections.
Dissertations and theses	ProQuest Digital Dissertations http://proquest.umi.com/pqdweb?RQT=302&cfc=1	Covers dissertations and theses from 1637 to the present.
Conference proceedings	ISI Proceedings http://wok.mimas.ac.uk/about/	Provides access to Thomson Scientific's products (including Web of Science, ISI Proceedings, and Journal Citation Reports).
	Zetoc http://zetoc.mimas.ac.uk/zetoc/	Covers journals and conference proceedings in science, medicine, engineering, and humanities.
Search Engines	Intute http://www.intute.ac.uk/socialsciences/search.html	Provides access to psychology resources.
	NLM Gateway http://gateway.nlm.nih.gov/gw/Cmd?GMOverview%26loc=lhc	Includes bibliographic and consumer health resources at the US National Library of Medicine (NLM).
	TRIS Online http://ntlsearch.bts.gov/tris/index.do	Contains technical reports, books, conference proceedings, and journal articles on various aspects of transportation.

APPENDIX B - A SUMMARY OF INCLUDED STUDIES IN THE SYSTEMATIC REVIEW OF THE LITERATURE

Author	Study looked at	Study type/design	Key findings
Baker, Myers, & Murphy (2007)	Perceptions of rail crowding, reliability, and frequency among rail users and non-rail users in the West Midlands, UK	Mixed-method – survey, qualitative research using focus groups, stated preference questionnaires	No effects of crowding were discussed, but the study found that the most important service attribute for a rail journey was overcrowding, followed by reliability and frequency. Overcrowding is perceived mainly as a result of unreliability combined with no extra carriages added.
Bottomley (1999)	Implications of overcrowding on trains	Review of evidence from rail accidents	No evidence suggesting passengers travelling on overcrowded trains are more at risk of a serious injury in the event of collision. Both seated and standing passengers are likely to be injured to an equal degree of severity in a crash at high speed. However, there is greater risk of injuries due to head-to-head collisions among standing passengers in overcrowded conditions.
Buckley & O'Regan (2004)	The psychological effects of commuting and the role of gender and perceived control as possible moderating factors of these effects	Cross-sectional survey – self-rating questionnaires	Commuters who travelled by train had higher levels of commuting stress and the most negative mood on arrival at work compared to other commuters in Dublin. The higher levels of stress and negative mood were found to be a result of the crowded conditions on the train services. The train commuters indicated that they would consider changing jobs because of the commute.
Cantwell, Caulfield, & O'Mahony (2009)	Stress due to commuting, and value placed on the comfort and reliability of public transport services	Online survey – stated preference scenarios	Commuting stress was higher among public transport users who travelled on crowded or unreliable services and those who have long waiting times. Analysis of the multinomial logit model showed that a reduction in crowding is more beneficial than an improvement in reliability.

Author	Study looked at	Study type/design	Key findings
Cassidy (1992)	Relationship between commuting and psychological and physical health problems	Cross-sectional survey – self-rating questionnaires	Longer commutes lead to a more negative experience of commuting. Effects of commuting reported include increased general stress levels, increased stress at home and at work, decreased life satisfaction, and a disruption of social, leisure, and home life; all of which depend on the impedance or difficulty experienced.
Cheng (2010)	Passenger anxieties associated with train travel in Taiwan	Cross-sectional survey – self-rating questionnaires, Rasch modelling	The paper highlights that crowding causes the highest level of passenger anxiety during train travel, followed by delays, accessibility to a railway station, searching for the right train on a platform, and transferring between trains.
Costa, Pickup, & DiMartino (1988)	The impact of commuting on the health and safety of workers	Cross-sectional survey – self-rating questionnaires	Public transport users suffer discomfort as a result of overcrowding, microclimatic conditions, noise, and vibrations, and face problems such as having to make more changes between modes, having idle waiting times, and delays leading to late arrival at work. Other consequences of commuting include increased stress (psychological annoyance), health complaints, absenteeism from work due to sickness, and tardiness as well as decreased performance at work.
Cox, Griffiths, & Houdmont (2003)	Rail safety as an issue and research opportunity for occupational health psychology	Commentary	The paper highlights two emerging issues: crowding on trains and crowded road-rail interfaces. Passenger density is related to, but does not solely determine, crowding. Some moderating factors between passenger density and perceived crowding are proposed, e.g. carriage design and the quality of the social and ambient physical environments.

Author	Study looked at	Study type/design	Key findings
Cox, Houdmont, & Griffiths (2006)	Crowding on trains and its relationship with passenger health and safety	Literature review	The paper argues that crowding is a possible threat to the healthiness of the rail industry and passengers and proposes a working model on the effects of rail passenger crowding linking passenger density and perceived crowdedness to the experience of stress (which affects individual and organisational health) with potential moderating factors (e.g. perception of risk of injury or crime, comfort and stress, i.e. psychological annoyance in relation to temperature, noise, vibration, ride quality, and seat design, lack of perceived control over proximity to others, space, or time, unpredictability of journey or the reliability of the services, and dissatisfaction with living and working conditions) operating throughout. The paper also suggests that interpersonal stress is likely to have spillover effects, e.g. stressful transport services lead to stressed workers, who in turn contribute to decreased productivity.
Cox, Lotinga, Houdmont, & Griffiths, (2002)	Relationship between crowding and health and safety in rail travel	Literature review	The paper asserts that studies of crowding in other environments (e.g. residential, prisons, etc.) add little value or knowledge in relation to rail travel. Crowding is regarded as having an 'indirect' effect and is a potential threat to health and safety, with potential moderators such as perceived control, predictability, and time urgency possibly influencing this relationship. Crowding perception and stress may be heightened by factors that increase discomfort such as temperature, noise, vibration, and seating.

Author	Study looked at	Study type/design	Key findings
Davis Associates (2008)	Identification of passenger behaviours on trains and platforms in crowded and crowd-developing situations	Mixed-method – literature review, passenger behaviour research, injury and incident analyses, stakeholder consultation, current practice review	The report identifies 92 behavioural influencing factors that describe how and why passengers' behaviour is affected during crowded or crowd-developing situations. Other key findings include: 1) passengers tend to avoid crowded situations and that they 'choose to position themselves away from others to maintain a space around them and minimise discomfort'; 2) the emotional state prior to the journey can affect passengers' tolerance towards others; 3) passengers are likely to be in a 'positive emotional state' if their train is punctual and announcements are audible and comprehensible, and in a 'negative' frame of mind if the service is late and no information is given; and 4) 63 controls for managing on-train crowding are proposed for operational situations and rolling stock design.
Dodgson, Kelso, Van der Veer, Skene, & Parades (2002)	Benchmarking study comparing London Underground services with standards achieved in six overseas metro systems, one of which is crowding and capacity level	Archival data from cross-system comparisons	The report recognises that the levels of overcrowding have been increasing and that the crowded conditions contribute to physical and psychological discomfort, illnesses, and injuries. However, international comparisons of crowding levels are difficult to make because (1) London average capacity utilisation figures are distorted by the suburban nature of many routes, and (2) different crowding measures are used (i.e. LUL uses PIXCs whereas other comparators' statistics look at the amount of standing space that each passenger has).

Author	Study looked at	Study type/design	Key findings
Evans & Wener (2006)	The role of commuting duration on the perception of stress	Cross-sectional survey – self and spouse-rating questionnaires, salivary cortisol, persistence and motivation measures	Longer commutes were significantly associated with elevated cortisol, poorer proofreading performance, and higher levels of perceived commuting stress. Although the findings only addressed the commuting duration's influence on stress, it can be implied that longer commutes may also affect the perception of crowding and experience of stress.
Evans & Wener (2007)	Possible contributions of train density and seat proximity to stress among passenger train commuters	Cross-sectional survey – self-rating questionnaires, salivary cortisol, persistence and motivation measures	Physiological stress (measured by salivary cortisol, task persistence (proofreading task) and mood (feeling burdened or frustrated) were all adversely affected under higher row densities, but not under higher carriage densities. The study concludes that the immediate, close presence of other passengers is more salient for the experience of crowding on public transport than the total number of people in the car.
Evans, Wener, & Phillips (2002)	The role of commute unpredictability on the perception of stress	Quasi-experiment – field study, self-rating questionnaires, salivary cortisol, persistence and motivation measures	Participants who perceived their commute to work as more unpredictable felt greater levels of stress and had higher elevations of salivary cortisol. Predictability of the commute, however, had no effect on task performance. It is assumed that since the study was conducted during the morning rush hour, hence 'crowded', commute unpredictability may also influence the perception of crowding and experience of stress.

Author	Study looked at	Study type/design	Key findings
Fritz (1983)	The effects of passenger congestion on level of service and dwell times	Observations of passenger transaction, mathematical modelling	The paper reports that crowding affects train performance in terms of boarding rates, i.e. boarding rates decreased when passenger congestion increased. It also offers an objective and quantitative method of defining crowding, i.e. nominal standee space would be $2.7ft^2$ per standee, while crush capacity density would be approximately $1.5ft^2$ per standee.
Gershon, Qureshi, Barrera, Erwin, & Goldsmith (2005)	Potential health and safety hazards associated with subways and risk management strategies that minimize the risk of the hazards	Literature review	Hazards associated with subways identified include 1) general safety, e.g. injuries due to congested pathways, constricted platforms, and crowded stairs; 2) security and violence, e.g. confined, overcrowded spaces, and off-peak hours can provide a climate for crime and a climate for the fear of crime; 3) the issue of noise and noise pollution; and 4) other miscellaneous hazards such as whole-body vibration, excessive exposure to heat, psychosocial stress in both workers and passengers, poor air quality, potential transmission of infectious diseases, electromagnetic field radiation, and terrorist threats or attacks on subways.
Gilbey, Drake, Lightfoot, & O'Dwyer (2006)	The effect of crowding on thermal stress	Simulation studies using whole carriage computational fluid dynamics model	The effect of crowding density on passengers' thermal strain is significant, but not as significant as hypothesised, while the combined effects of crowding and ventilation are more significant on CO^2 levels than on thermal strain. The paper suggests that evaluation of the effect of crowding is important in any future calculations of thermal strain within trains.

Author	Study looked at	Study type/design	Key findings
House of Commons Transport Committee (2003)	Overcrowding on public transport	Public inquiry – official review of written and oral evidence	Overcrowding on public transport is a significant problem, but current practices and policies are inadequate to address the problem. Poor service reliability, capacity constraints, lack of train availability, and inappropriate train formations and timetables which do not provide enough capacity at the right times have significant impact on crowding. The report points to evidence of 1) public transport overcrowding and delays impacting business (e.g. lateness at work, loss of productivity, sickness absence, missed and rescheduled meetings, and lost business) and tourism (e.g. seasonal congestion discourages tourists, hence loss of income); 2) the lack of adequate rail and bus capacity during peak periods; and 3) the inadequacy of rail capacity measurement, i.e. PIXC data reported by the train operating companies does not show the most crowded routes.
Lam, Cheung, & Lam (1999)	Crowding effects and train dwelling times at the LRT stations in Hong Kong	Cross-sectional surveys – stated preference questionnaires, mathematical modelling	The number of passengers boarding and alighting influences train dwelling times, causing delayed departures and reduced service frequency and capacity, which, in turn, leads to even more overcrowding. The paper also demonstrates how crowding is measured, i.e. using LOS for platform crowding and DOC for on-train crowding.
Lam, Cheung, & Poon (1999)	Crowding effects during peak periods at the MTR stations in Hong Kong	Cross-sectional surveys – stated preference questionnaires, mathematical modelling	Passengers are willing to travel with additional travel penalty (experiencing body contact with other passengers) when the in-vehicle travel times are 10 to 20 minutes. Crowding conditions on platforms make passengers choose a better level of service even though additional on-platform waiting time is required.

Author	Study looked at	Study type/design	Key findings
Lerer & Matzopolous (1996)	The epidemiology of railway-related injuries in Cape Town	Review of evidence on railway-related injuries	The study highlights the health and safety hazards associated with railways. In particular, overcrowding and risk-taking behaviour were regarded as the main causes of fall-from-train incidents.
London Assembly Transport Committee (2009a)	Analysis of the long-term prospects for overcrowding on London's overground train services	Review of written and oral evidence	The report identifies the busiest rail routes into London and found that the most crowded trains carry 40% more passengers than their capacity during peak periods. It also notes that this situation is unlikely to improve significantly for many commuters despite the changes promised. A standard methodology for measuring rail overcrowding that takes into account figures on passengers per square metre on trains, data on crowding during the one-hour high peak, and disaggregates data on trains to show levels of overcrowding is recommended.
London Assembly Transport Committee (2009b)	Passengers' experiences of overcrowding and line closures on the London Underground	Mixed-method – group discussions, travel diaries, online survey, review of oral and written information	Overcrowding causes discomfort and stress as well as frustration for not being able to board the first train to arrive, which, in turn, affects passengers' behaviour and travel choices. The coping behaviours adopted by these passengers range from becoming more ruthless to 'shutting down'.
Lundberg (1976)	Stress-related arousal in high-density trains	Quasi-experiment – field study, catecholamine, self-rating questionnaires	Perceptions of crowding and levels of physiological stress (via catecholamine excretion from urine samples) and psychological stress (via self-reporting questionnaires on comfort and unpleasantness) increased under conditions of higher passenger density. But those who had been on the train since the start showed less stress, even though they had been exposed to the crowded conditions for a longer period. Concludes that being able to choose a seat, i.e. control the situation, may reduce stress.

Author	Study looked at	Study type/design	Key findings
McLennan & Bennetts (2003)	Facilities manager's scope for addressing the use of public transport as a workplace, and the health and well-being implications of commuting	Cross-sectional survey – self-administered descriptive questionnaires	Reported stress and productivity decrements vary with length of journey and travel mode: stress reported mostly by employees who are long-distance automobile commuters and short-distance public transport users. Employees place great importance on personal control of the journey and savings in journey time in determining travel choice, and recognise some difficulties for public transport in meeting this criterion.
National Audit Office (2000)	Challenges faced by the Strategic Rail Authority (SRA) in its task of improving passenger rail services	Mixed-method – analysis of train operating company performance data, interviews and discussions, consultations with stakeholders and expert advisers	The report urges the rail authorities to put more effort into dealing with issues of late services, overcrowded trains, and inadequate stations. Passenger growth and limited network capacity contribute to increased levels of overcrowding. Information on overcrowding was infrequently collected, expensive to collate, unreliable, and covered only certain commuter routes. Overcrowding could be significantly reduced if train operators provide the capacity they promise in peak periods.
Nicol, Dore, Weiner, Lee, Prestidge, & Andrews (1973)	Passengers' reactions in different densities and various in-shed temperatures	Experiment	Passengers in ventilated but crowded trains will experience an undesirable and potentially dangerous level of discomfort after 30 minutes, with standing passengers commonly finding these conditions more severe. The study recommends that the globe temperature in a carriage should not exceed 30 °C in any case, with a physiological limit for safety of 30.6 °C.
Passenger Focus (2006)	Overcrowding issue from a passenger perspective	Review of written information	The report examines crowding and its impact on passengers, and concludes that a single, uniform approach is needed to address the issue. Overcrowding affects 1) train performance, e.g. causing delays to services; 2) safety, e.g. injuries, discomfort, stress, unsafe behaviours; and 3) employment, e.g. lateness to work, loss of productivity, sickness absence.

Author	Study looked at	Study type/design	Key findings
Pittard & Jackson (1992)	Evacuation performance from an overcrowded railway coach under competitive and non-competitive conditions	Experiment	No stress effects discussed, but the paper shows that different levels of loading or crowding (up to 135%) has little effect on the overall time taken to evacuate the carriage. Psychological factors such as individual's willingness to compete with others and their levels of self-consciousness play greater roles in predicting evacuation performance at higher density, i.e. 135% loading.
Singer, Lundberg, & Frankenhauser (1978)	Stress arising from commuting via public transport	Quasi-experiment – field study, epinephrine and cortisol levels, self-rating questionnaires	Commuting by train elevated psycho-physiological parameters such as blood pressure and neuroendocrine processes (measured by epinephrine and cortisol levels) indicative of stress. Passengers with longer trips are less stressed on the train than those with short trips, suggesting that having greater control over seat selection may moderate the relationship.
Taylor & Pocock (1972)	Comparisons of journeys to work and degree of crowding on public transport lines used with employees' records of sickness absence	Cross-sectional survey – self-rating questionnaires, sickness absence	There is no significant association between the use of public transport or any aspect of the journey (including crowdedness of the train) and the incidence of certified influenza. However, longer commuting distance and duration, i.e. more than 1.5 hours, the number of stages of the journey, and continually stressful commutes are related to work absenteeism.
Thomas, Rhind, & Robinson (2006)	Passenger perceptions of risk and safety preferences for implementing safety interventions	Mixed-method – stakeholder consultation, qualitative research using focus groups, self-rating questionnaires	Focus group's results highlighted crowding as one of the main concerns among rail passengers. Safety and risk awareness questionnaire results showed weak relationship between perceived and actual risks on the rail network.

Author	Study looked at	Study type/design	Key findings
Tian, Huang, & Yang (2007)	Equilibrium properties of the morning peak-period commuting pattern on a train with an in-vehicle crowding effect and schedule delay cost	Mathematical modelling	The study found that passengers' departure time choice is related to train's capacity. The equilibrium solutions propose that the following factors may contribute to crowding build-up: 1) commuters who live nearer to their workplace always ride the train together with commuters living further away from the workplace; 2) the train arriving at the time desired by everyone is utilised by commuters from all stations; and 3) a 'saturated' time period exists for each station during which the departure rate of commuters is identical and maximal.
Turner, Corbett, O'Hara, & White (2004)	Health and safety issues that may arise as a result of crowding (on trains and at stations) on mainline and underground railways	Mixed-method – literature review, accident and incident analyses, industry workshop, stakeholder consultation	A comprehensive report discussing the definition and measurement of rail crowding and the range of incidents that may involve crowding as a contributory factor to health and safety. Although the report concludes that there is little evidence linking crowding to health and safety issues due to the subjective nature of crowding, it also recognises crowding as a factor in a number of health and safety hazards, which becomes a more significant health and safety issue when combined with other factors, e.g. high temperatures, delays, train failures, unplanned events, etc. Other key findings include 1) the perception of risk from crowding appears higher among the stakeholders; 2) unlike crowding issues that are safety-related, health-related crowding issues are less understood, less controlled, and have less evidence, even though these are perceived to be significant; and 3) less consideration is given to assessing the health and safety effects of crowding on trains in comparison to crowding at stations.

Author	Study looked at	Study type/design	Key findings
Wener & Evans (2004)	Psychological and physiological stress experienced by train commuters and its spillover effects at work (Technical report)	Multi-method approach – quasi-experimental, pre- and post-change field research, self-rating questionnaires, salivary cortisol, persistence and motivation measures	Replication and extension of the Wener et al. study (2003) by adding work stress measures and recruiting more respondents. Verifies the findings that shorter, familiar, and convenient (i.e. direct route) journeys are less likely to cause increased stress (measured by salivary cortisol, proofreading task, and self-reporting questionnaires) and job strain, while those staying with the previous service, i.e. congested conditions, maintained their stress and job strain scores. The report also demonstrates how crowding is measured, i.e. using three indices: 1) counts of the number of empty seats and number of standing riders in the cars in which the passenger rides; 2) rating of levels of density and perceived crowding; and 3) counts of the number of other passenger seated in the Ss seating row and whether anyone was seated next to them.
Wener, Evans, & Boately (2005)	Journal article reporting Wener and Evans study (2004)	Multi-method approach similar to Wener and Evans' study (2004)	Results reported are the same as in Wener and Evans' study (2004).
Wener, Evans, & Lutin (2006)	Commuting stress disparity between commuting by car and public transit	Cross-sectional survey – self-rating questionnaires	Automobile commuters show significantly higher levels of reported stress and more negative moods, and indicate that the trip is significantly more effortful. They also feel that their trip is significantly less predictable compared to train commuters. Effort mediates the effect of commuting mode on stress.

Author	Study looked at	Study type/design	Key findings
Wener, Evans, Phillips, & Nadler (2003)	The nature and quality of mass transit commutes and commuter stress and spill-over effects at home	Multi-method approach – quasi-experimental, pre and post change field research, self and spouse-rating questionnaires, salivary cortisol, persistence and motivation measures	Commuters who switch to a 'one-seat ride' in a direct rail service experience reduced stress as shown by physiological measures (salivary cortisol), psychological stress/annoyance (self-reporting questionnaires), and persistence and motivation measures (proofreading task). Time of the trip mediated this relationship. Predictability of the trip is inversely correlated with stress, but does not distinguish between the commuter groups. Negative spillover effects at home (measured by spouse-rating questionnaires) were not statistically significant, but results were in the predicted direction, i.e. commuters who have to transfer to another train show more stress at home.
Weyman, O'Hara, & Jackson (2005)	Human factor issues relating to passenger egress and evacuation	Review of evidence – observations, site visits, video footage and still photographs, witness statements, technical reports, and seating plans	The paper does not specifically discuss the effects of rail crowding but reveals three crowding-related hazards with regard to passenger escape and evacuation based on the Ladbroke Grove train crash: 1) passengers' mental models in emergency egress situations; 2) intuition and situation awareness when designing communication systems; and 3) emergency egress equipment for the railway carriage environment.
Whelan & Crockett (2009)	Obtaining robust estimates of the valuation of overcrowding across the range of contexts in which it may occur	Market research – focus groups, in-depth cognitive interviews, and web and paper-based questionnaires collecting transfer price, revealed preference, and stated preference data	The study found that rail users are willing to pay more for a less crowded trip, expressed in terms of the probability of getting a seat.

APPENDIX C – SYNTAX FOR POWER ANALYSIS

R version 2.9.2 (2009-08-24) ISBN 3-900051-07-0
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```
Rweb:> postscript(file= "/tmp/Rout.15657.ps")
Rweb:>
Rweb:> #Computation of minimum sample size for test of fit
Rweb:>
Rweb:> rmsea0 <- 0.05 #null hypothesized RMSEA
Rweb:> rmseaa <- 0.01 #alternative hypothesized RMSEA
Rweb:> d <- 42 #degrees of freedom
Rweb:> alpha <- 0.05 #alpha level
Rweb:> desired <- 0.8 #desired power
Rweb:>
Rweb:> #Code below need not be changed by user
Rweb:> #initialize values
Rweb:> pow <- 0.0
Rweb:> n <- 0
Rweb:> #begin loop for finding initial level of n
Rweb:> while (pow<-="" n+100="" ncp0="" (n-1)*d*rmsea0^2="" ncpa="" (n-
1)*d*rmseaa^2="" #compute="" power="" if(rmsea0
Rweb:> #begin loop for interval halving
Rweb:> foo <- -1
Rweb:> newn <- n
Rweb:> interval <- 200
Rweb:> powdiff <- pow - desired
Rweb:> while (powdiff>.001) {
+   interval <- interval*.5
+   newn <- newn + foo*interval*.5
+   ncp0 <- (newn-1)*d*rmsea0^2
+   ncpa <- (newn-1)*d*rmseaa^2
+   #compute power
+   if(rmsea0<-="" qchisq(alpha,d,ncp="ncp0,lower.tail=F)" pow=""
pchisq(cval,d,ncp="ncpa,lower.tail=F)" }="" else="" qchisq(1-
alpha,d,ncp="ncp0,lower.tail=F)" 1-pchisq(cval,d,ncp="ncpa,lower.tail=F)" powdiff=""
abs(pow-desired)="" if="" (powdesired) {
+     foo <- -1
+   }
+ }
Rweb:>
Rweb:> minn <- newn
Rweb:> print(minn)
[1] 296.875
Rweb:>
Rweb:>
```

APPENDIX D - KEY STAKEHOLDER SCOPING QUESTIONNAIRE

KEY STAKEHOLDER SCOPING SURVEY

The Quality of Rail Passenger Experience Research is a joint Institute of Work, Health, and Organisations (IWHO), University of Nottingham, United Kingdom and International Islamic University, Malaysia (IIUM) effort to communicate your experiences and future plans, to be translated into scientific reports, which will provide validated data and analyses that you can use to facilitate improvements in the service quality of public transportation, particularly the rail passenger services.

You are invited to participate in this research because of your role as the key stakeholder of the rail services in Malaysia. Your input as the key stakeholder is essential in determining the future of rail transport needs and your ideas about how to improve the service are welcome.

Purpose of the questionnaire

The purpose of this questionnaire is to gather information from the stakeholders in the urban rail transit industry about: (1) ridership, (2) reliability and service quality, (3) passenger load and train capacity, (4) key operational issues the rail operators and related organisations find challenging, and (5) key strategic issues and future planning to tackle these challenges.

After completion of the questionnaire, please save this document electronically to your personal folder and return the questionnaire to the researcher as an attachment via e-mail to:

railpassenger0810@yahoo.co.uk or lwxndm@nottingham.ac.uk.

You can also contact me on the following contact details if you have any questions about the content of this questionnaire.

Tel: +44 (0)781 0461902
Fax: +44 (0)115 8466625

We can assure you that your responses will be treated in the strictest confidence.
Your valuable support and contribution are greatly appreciated.

PART 1
1. Can you provide us your ridership statistics?
2. Do you have individual route peak point ridership data?
3. Do you have riding counts or ride-checks?
4. Do you have any published standards or policies on passenger traffic that you can send us? If Yes, please provide the info.
5. Do you have any information about your passenger profile that you can send us? If Yes, please provide the info.

PART 2

1. Can you provide us data on the following items:

Frequencies of trains	
Number or percentage of delays	
Number or percentage of headways missed	
Number or percentage of trains cancelled	
Percentage of escalators / lifts out of service	
Average waiting time	

2. Are there any benchmarking studies comparing your line with overseas railways? If so, what do they show? If Yes, please provide the info.

3. How do you rate the current service quality provided by your line (for example, in terms of reliability, punctuality, safety and security, travel comfort, and customer information)?

Reliability	
Punctuality	
Safety and security	
Travel comfort	
Customer information	
Others	

PART 3

1. How do you calculate the loading level of your rail system? Are there any guidelines or standards that you can send us on this?

2. Do you maintain data on peak-time crowding statistics? Can you provide us with this information?

3. Do you measure the ratio ridership to capacity? If Yes, can you provide the ratio?

4. What is the rail transit capacity of your line? Is this determined by a formula?

PART 4

1. What are your organisations specific issues and concerns regarding rail passenger services?

2. How important is passenger crowding to these issues?

PART 5

1. Do you have any plans to expand over the next five years?

2. What would you say are the biggest challenges facing train operating companies at the moment? Are there any particular issues which are constraining the industry?

3. What could be done (for example, by the government, customers) to overcome some of the barriers you have identified?

4. What could your organisation do to facilitate these efforts, especially in terms of crowding issues?

YOUR DETAILS

Name: ____________________

Job title: ____________________

Organisation: ____________________

Tel. no.: ____________________

Fax no.: ____________________

E-mail: ____________________

Thank you very much for taking time to complete this questionnaire.

APPENDIX E - PASSENGER SURVEY QUESTIONNAIRE

RESEARCH ON THE QUALITY OF RAIL PASSENGER EXPERIENCE IN MALAYSIA AND ITS IMPACT ON COMMUTERS' WORK AND LIFE

EPU REF NO: UPE:40/200/19/2410

Researchers at University of Nottingham, United Kingdom and International Islamic University Malaysia are currently conducting a study to investigate how rail crowding may affect passengers' commuting experience and whether or not these effects spill over to work (e.g. job satisfaction, intention to quit etc.) and life (e.g. individual health etc.). Since little is known about these effects, your comments on the aspects covered here are very much appreciated.

Being involved in our study will offer you interesting and valuable opportunities to share your own commuting experiences and to voice out your ideas on how we can improve (1) our rail passenger services, and (2) the overall passengers' commuting experience. The more that is known about this issue, the better interventions can be suggested.

Please be assured that all information you provide will be kept strictly confidential and will only be used for research purposes.

Due to the dedication, time, and effort required by participation in this study, you will receive **RM20.00** for the questionnaire that you have correctly completed.

Your Task

There are **SIX (6)** parts in this questionnaire. The parts are:

Part 1:	Background Information	Section A
Part 2:	Your Journey Today	Section B & C
Part 3:	Your Journey In General	Section D & E
Part 4:	Your Commute And Your Job	Section F, G, & H
Part 5:	Your Life And Overall Well-being	Section I & J
Part 6:	About You	

Please read and answer **ALL** questions carefully **by circling or ticking the appropriate checkboxes** provided. In specific questions, you may circle or tick more than one option and supply information where required.

If there is anything that seems unclear or if you have any questions regarding this research, please feel free to contact Nor Diana Mohd Mahudin at **016-2876431** *or* **railpassenger0810@yahoo.co.uk**.

We would like to receive your answers ***before* _______________.**

Thank you for your important contribution!

The Quality of Rail Passenger Experience in Malaysia Research is an independent, academic research project and is not affiliated with any particular rail passenger organisations or groups.

PART 1: BACKGROUND	
A	**PLEASE CIRCLE OR TICK THE APPROPRIATE CHECKBOXES PROVIDED. IN SPECIFIC QUESTIONS, PLEASE SUPPLY THE INFORMATION REQUIRED.**

1a. Name of the rail line that you use for your regular daily commute to/from work:

LRT Kelana Jaya line	....	KTM Komuter Rawang-Seremban	....
LRT Ampang Line	....	Transfer/ transit (Please provide details)	....
KTM Komuter Sentul-Klang	....	________________________	

2a. How long have you been using this rail line on a regular basis?

1 – 6 months	....	5 – 9 years	....
6 – 12 months	....	10 years or more	....
1 – 4 years	....	Never / First time today	....

3a. How often do you make this journey to go to work?

3 or more times a week	....	Once every 2-3 months	....
Once or twice a week	....	Less often	....
1 or 2 times a month	....	Never / First time today	....

4a. On average, how long does it take you to commute…

From home to work	.	minutes
From work to home	.	minutes

5a. On a **BAD** day, how long does it take you **to commute ONE-WAY?** *("**BAD**" refers for example- trains are facing technical problems; could not get on train as it was overcrowded; the train that you had planned to catch was cancelled; service interruptions etc.)* . minutes

6a. On a **GOOD** day, how long does it take you **to commute ONE-WAY?** *("**GOOD**" refers for example- trains are running on time and according to schedule; no waiting at the platform; not crowded; no technical problems etc.)* . minutes

7a. How long do you usually have to wait for your train? . minutes

8a. How would you describe a typical trip over the past month?

There are always seats available.	☐	I usually stand and it is crowded.	☐
There are usually seats available.	☐	I usually stand and it is <u>very</u> crowded.	☐
I usually stand but there is space for standing.	☐	It varies.	☐

9a. How often do you encounter delays during your commute to work?

Not at all	**Sometimes**	**Often**	**All the time**
1	**2**	**3**	**4**
☐	☐	☐	☐

10a. In general, how reliable is your rail services?

Extremely unreliable	**Unreliable**	**Somewhat unreliable**	**Somewhat reliable**	**Reliable**	**Extremely reliable**
1	**2**	**3**	**4**	**5**	**6**
☐	☐	☐	☐	☐	☐

11a. In your opinion, what could the train operating companies / rail operators do to reduce the **feeling of crowdedness <u>on the train</u>** experienced by the commuters?

PART 2: YOUR JOURNEY TODAY

B	**PLEASE CIRCLE OR TICK THE APPROPRIATE CHECKBOXES PROVIDED. IN SPECIFIC QUESTIONS, PLEASE SUPPLY THE INFORMATION REQUIRED.**

1b. What time did you **leave home TODAY** for your morning commute to work? [.] AM

2b. How did you travel **to** your local train station **TODAY**? (Use all that apply). "I ….

…drove/ parked a car at / near station."	approx time of trip	________	minutes
…was given a car ride to station."	approx time of trip	________	minutes
…car pooled to station."	approx time of trip	________	minutes
…took a bus to station."	approx time of trip	________	minutes
…took a taxi / cab to station."	approx time of trip	________	minutes
…rode a motorcycle to station."	approx time of trip	________	minutes
…bicycled to station."	approx time of trip	________	minutes
…walked to station."	approx time of trip	________	minutes

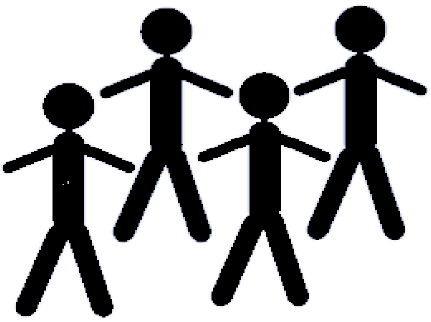
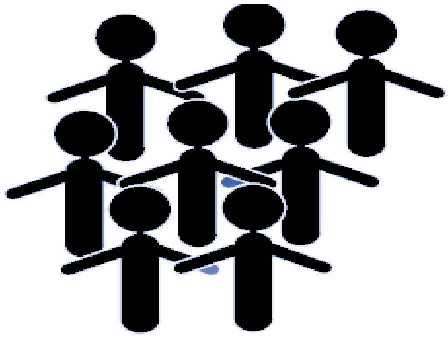
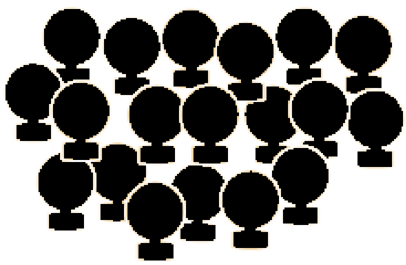
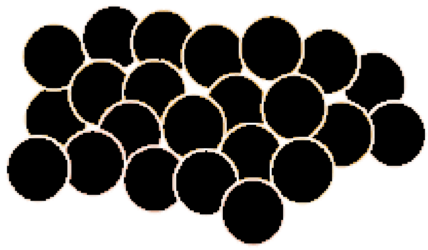
Other or additional modes used to get to station: [.]

3b. Name of the departing train station: [.]

4b. Did you **get a seat TODAY?** [….] Yes [….] No

5b. What time did you **arrive at work TODAY** from your morning commute? [.] AM

6b. Name of the arriving train station: [.]

7b.	How crowded is the train that you are on **TODAY**?
 1. All of body visible: **No crowd issues**	 2. Only body & head visible: **Slightly Crowded**
 3. Only shoulder & head visible: **Crowded**	 4. Only head visible: **Extremely crowded**

8b.	**BELOW ARE 7 CATEGORIES OF ITEMS THAT ASK YOU ABOUT "<u>HOW CROWDED IS THE TRAIN THAT YOU ARE ON TODAY</u>" (A, B, C, D, E, F, & G). PLEASE CIRCLE OR TICK ONE ANSWER IN EACH OF THESE CATEGORIES.**

A	**5**	Extremely dense	**B**	**5**	Extremely disorderly	**C**	**5**	Extremely confining	**D**	**5**	Extremely unpleasant
	4	Very dense		**4**	Very disorderly		**4**	Very confining		**4**	Very unpleasant
	3	Dense		**3**	Disorderly		**3**	Confining		**3**	Unpleasant
	2	Slightly dense		**2**	Slightly disorderly		**2**	Slightly confining		**2**	Slightly unpleasant
	1	Not dense		**1**	Not disorderly		**1**	Not confining		**1**	Not unpleasant

E	**5**	Extremely chaotic	**F**	**5**	Extremely disturbing	**G**	**5**	Extremely cluttered
	4	Very chaotic		**4**	Very disturbing		**4**	Very cluttered
	3	Chaotic		**3**	Disturbing		**3**	Cluttered
	2	Slightly chaotic		**2**	Slightly disturbing		**2**	Slightly cluttered
	1	Not chaotic		**1**	Not disturbing		**1**	Not cluttered

9b	BELOW ARE 9 CATEGORIES OF ITEMS THAT ASK YOU ABOUT "<u>HOW YOU FEEL INSIDE THE TRAIN THAT YOU COMMUTE ON TODAY</u>" (A, B, C, D, E, F, G, H, & I). PLEASE CIRCLE OR TICK ONE ANSWER IN EACH OF THESE CATEGORIES.										
A	**5**	Extremely squashed	**B**	**5**	Extremely tensed	**C**	**5**	Extremely distracted	**D**	**5**	Extremely uncomfortable
	4	Very squashed		**4**	Very tensed		**4**	Very distracted		**4**	Very uncomfortable
	3	Squashed		**3**	Tensed		**3**	Distracted		**3**	Uncomfortable
	2	Slightly squashed		**2**	Slightly tensed		**2**	Slightly distracted		**2**	Slightly uncomfortable
	1	Not squashed		**1**	Not tensed		**1**	Not distracted		**1**	Not uncomfortable
E	**5**	Extremely frustrated	**F**	**5**	Extremely restricted	**G**	**5**	Extremely irritable	**H**	**5**	Extremely hindered
	4	Very frustrated		**4**	Very restricted		**4**	Very irritable		**4**	Very hindered
	3	Frustrated		**3**	Restricted		**3**	Irritable		**3**	Hindered
	2	Slightly frustrated		**2**	Slightly restricted		**2**	Slightly irritable		**2**	Slightly hindered
	1	Not frustrated		**1**	Not restricted		**1**	Not irritable		**1**	Not hindered
I	**5**	Extremely stressful									
	4	Very stressful									
	3	Stressful									
	2	Slightly stressful									
	1	Not stressful									

10b	BELOW ARE 4 CATEGORIES OF ITEMS THAT ASK YOU ABOUT "<u>THE PHYSICAL ENVIRONMENT INSIDE THE TRAIN THAT YOU COMMUTE ON TODAY</u>" (A, B, C, & D). PLEASE CIRCLE OR TICK ONE ANSWER IN EACH OF THESE CATEGORIES.										
A	**5**	Extremely hot	**B**	**5**	Extremely stuffy	**C**	**5**	Extremely smelly	**D**	**5**	Extremely noisy
	4	Very hot		**4**	Very stuffy		**4**	Very smelly		**4**	Very noisy
	3	Hot		**3**	Stuffy		**3**	Smelly		**3**	Noisy
	2	Slightly hot		**2**	Slightly stuffy		**2**	Slightly smelly		**2**	Slightly noisy
	1	Not hot		**1**	Not stuffy		**1**	Not smelly		**1**	Not noisy

	C	**THE ADJECTIVES SHOWN BELOW DESCRIBE DIFFERENT FEELINGS AND MOODS.** **PLEASE USE THIS LIST TO DESCRIBE <u>YOUR MOODS AND FEELINGS WHILE ON THE TRAIN TODAY</u>.**

If the adjective **<u>DEFINITELY DESCRIBES YOUR FEELINGS</u> ON THE TRAIN TODAY,** circle the ++

If the adjective **<u>MORE OR LESS DESCRIBES YOUR FEELINGS</u> ON THE TRAIN TODAY,** circle the +

If you **<u>DO NOT UNDERSTAND</u> THE ADJECTIVE, OR YOU <u>CANNOT DECIDE WHETHER IT DESCRIBES</u> HOW YOU FEEL ON THE TRAIN TODAY**, circle the ?

If the adjective **<u>DOES NOT DESCRIBE</u> THE WAY YOU FEEL ON THE TRAIN TODAY,** circle the -

Your first reactions will be the most reliable; therefore do not spend too long thinking about each adjective.

****

1c.	Tense	++	+	?	-	16c.	Tired	++	+	?	-
2c.	Relaxed	++	+	?	-	17c.	Idle	++	+	?	-
3c.	Restful	++	+	?	-	18c.	Up tight	++	+	?	-
4c.	Active	++	+	?	-	19c.	Alert	++	+	?	-
5c.	Apprehensive	++	+	?	-	20c.	Lively	++	+	?	-
6c.	Worried	++	+	?	-	21c.	Cheerful	++	+	?	-
7c.	Energetic	++	+	?	-	22c.	Contented	++	+	?	-
8c.	Drowsy	++	+	?	-	23c.	Jittery	++	+	?	-
9c.	Bothered	++	+	?	-	24c.	Sluggish	++	+	?	-
10c.	Uneasy	++	+	?	-	25c.	Pleasant	++	+	?	-
11c.	Dejected	++	+	?	-	26c.	Sleepy	++	+	?	-
12c.	Nervous	++	+	?	-	27c.	Comfortable	++	+	?	-
13c.	Distressed	++	+	?	-	28c.	Calm	++	+	?	-
14c.	Vigorous	++	+	?	-	29c.	Stimulated	++	+	?	-
15c.	Peaceful	++	+	?	-	30c.	Activated	++	+	?	-

PART 3: YOUR JOURNEY IN GENERAL

D **PLEASE RATE THE DEGREE OF YOUR AGREEMENT WITH EACH OF THE FOLLOWING STATEMENTS ABOUT YOUR COMMUTE IN GENERAL. PLEASE CIRCLE OR TICK THE APPROPRIATE CHECKBOXES PROVIDED.**

		Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
1d.	I have no choice about how I commute to work.	1	2	3	4	5	6
2d.	I feel there is little or nothing I can do to control the way in which I commute to work.	1	2	3	4	5	6
3d.	I have no control over the duration of my commute.	1	2	3	4	5	6
4d.	I feel helpless when the train that I had planned to catch is delayed.	1	2	3	4	5	6
5d.	I have no control over what time I get to work or get home.	1	2	3	4	5	6
6d.	It takes a lot of effort to commute to work.	1	2	3	4	5	6
7d.	My commute to work takes a lot of energy.	1	2	3	4	5	6
8d.	I feel overloaded when the train that I commute on is crowded.	1	2	3	4	5	6
9d.	Commuting to work is exhausting.	1	2	3	4	5	6
10d.	Overall, commuting is stressful for me.	1	2	3	4	5	6
11d.	I dislike the hassles caused by my commute.	1	2	3	4	5	6
12d.	I dislike the length of my commute to work.	1	2	3	4	5	6
13d.	I am usually worried when commuting on the train.	1	2	3	4	5	6
14d.	I often feel tired while at work.	1	2	3	4	5	6
15d.	In general, I feel extremely negative about my commute.	1	2	3	4	5	6
16d.	My journey time to work is unpredictable.	1	2	3	4	5	6
17d.	Unexpected service disruption makes my commute inconsistent.	1	2	3	4	5	6
18d.	Traffic congestion makes my commute to work less predictable.	1	2	3	4	5	6
19d.	Overcrowded trains caused my commute to be unpredictable.	1	2	3	4	5	6

		Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
20d.	In general, I cannot predict how long will it take for my daily commute to work.	1	2	3	4	5	6
21d.	There is not enough space on the train for commuters.	1	2	3	4	5	6
22d.	When I am commuting, people are standing or sitting too close to me.	1	2	3	4	5	6
23d.	The close presence of strangers around me on the train makes my commute unpleasant.	1	2	3	4	5	6
24d.	I feel my personal space has been intruded while on the train.	1	2	3	4	5	6
25d.	Having lack of privacy on the train bothers me.	1	2	3	4	5	6
26d.	I avoid unnecessary interaction with people during my commute.	1	2	3	4	5	6
27d.	I would be willing to quit my current job in order to take a job closer to home.	1	2	3	4	5	6
28d.	I would be willing to move closer to my job to shorten my commute.	1	2	3	4	5	6
29d.	I would use another form of transportation if I could afford it.	1	2	3	4	5	6

	If you wanted to relocate to avoid crowded commute, how feasible would it be for you to… **(Please circle/tick ONE choice for each question):**	**Not at all feasible** 1	**Un-feasible** 2	**Somewh at unfeasibl e** 3	**Feasible** 4	**Some-what feasibl e** 5	**Quite feasible** 6
30d.	Change your place of residence (house location)	1	2	3	4	5	6
31d.	Change your place of work	1	2	3	4	5	6

	E	**PHYSICAL SYMPTOMS** **PLEASE CIRCLE/TICK ONE CHOICE FOR EACH QUESTION.**

I suffer physical symptoms of stress as a result of my commute such as… **(You may circle/tick more than one option):**

Headaches	….	Sweaty palms	….	Stiff muscles / neck	….
Sleeplessness	….	Feel tired a lot	….	Irritability	….
Increased heart beat	….	Feel angry a lot	….	Difficulty focusing attention	….
Nervousness	….	Lower back pain	….	Tension	….
Stomach upset	….	Breathing difficulty	….		

Other (Please specify):

PART 4: SECTIONS F, G, AND H ASK QUESTIONS ABOUT YOUR COMMUTE AND YOUR JOB.

	F	**PLEASE SUPPLY THE INFORMATION REQUIRED.**		
		In the past 4 weeks, how many days…		
1f.		…have you been **late to work** due to your commute?	_______________	Day(s)
2f.		…have you been **later than expected getting home from work** due to your commute?	_______________	Day(s)
3f.		…did you **leave your house early** to avoid rush hour?	_______________	Day(s)
4f.		…did you **leave work early or late** to avoid rush hour?	_______________	Day(s)
5f.		…did you **miss an entire day of work because of your commute?**	_______________	Day(s)
6f.		…did you **miss part of a work day because of your commute?**	_______________	Day(s)

G — **PLEASE RATE THE DEGREE OF YOUR AGREEMENT WITH EACH OF THE FOLLOWING STATEMENTS ABOUT YOUR JOB. PLEASE CIRCLE/TICK ONE CHOICE FOR EACH QUESTION.**

		Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
1g.	I often think about quitting my job.	1	2	3	4	5	6
2g.	I intend to leave my company soon.	1	2	3	4	5	6
3g.	I will quit my job as soon as possible.	1	2	3	4	5	6
4g.	I will probably look for a new job next year.	1	2	3	4	5	6
5g.	I do not plan on leaving my company.	1	2	3	4	5	6

H — **ASK YOURSELF, "HOW SATISFIED AM I WITH THIS ASPECT OF MY JOB?" PLEASE CIRCLE/TICK ONE CHOICE FOR EACH QUESTION.**

		Not satisfied	Somewhat satisfied	Satisfied	Very satisfied	Extremely satisfied
1h.	Being able to keep busy all the time.	1	2	3	4	5
2h.	The chance to work independently on the job.	1	2	3	4	5

3h.	The chance to do different things from time to time.	**1**	**2**	**3**	**4**	**5**
4h.	The chance to be "somebody" in my company.	**1**	**2**	**3**	**4**	**5**
5h.	The way my boss handles his/her workers.	**1**	**2**	**3**	**4**	**5**
6h.	The competence of my supervisor in making decisions.	**1**	**2**	**3**	**4**	**5**
7h.	Being able to perform job activities that are not against my conscience.	**1**	**2**	**3**	**4**	**5**
8h.	The way my job provides for steady employment.	**1**	**2**	**3**	**4**	**5**
9h.	The chance to do things for other people.	**1**	**2**	**3**	**4**	**5**
10h.	The chance to tell people what to do.	**1**	**2**	**3**	**4**	**5**
11h.	The chance to do something that makes use of my abilities.	**1**	**2**	**3**	**4**	**5**
12h.	The way company policies are put into practice.	**1**	**2**	**3**	**4**	**5**
13h.	My pay and the amount of work I do.	**1**	**2**	**3**	**4**	**5**
14h.	The chances for advancement on this job.	**1**	**2**	**3**	**4**	**5**
15h.	The freedom to use my own judgment.	**1**	**2**	**3**	**4**	**5**
16h.	The chance to try my own methods of doing the job.	**1**	**2**	**3**	**4**	**5**
17h.	The working conditions.	**1**	**2**	**3**	**4**	**5**
18h.	The way my co-workers get along with each other.	**1**	**2**	**3**	**4**	**5**
19h.	The praise I get for doing a good job.	**1**	**2**	**3**	**4**	**5**
20h.	The feeling of accomplishment I get from the job.	**1**	**2**	**3**	**4**	**5**

PART 5: SECTION I AND J ASK QUESTIONS ABOUT YOUR LIFE AND OVERALL WELL-BEING.

I **PLEASE READ EACH QUESTION CAREFULLY AND DECIDE HOW OFTEN, OVER THE LAST SIX MONTHS, YOU HAVE EXPERIENCED THE VARIOUS SYMPTOMS THAT ARE LISTED.**
PLEASE CIRCLE/TICK ONE CHOICE FOR EACH QUESTION.

		Never	Rarely	Some times	Often	All the time
1i.	Become easily bored?	**0**	**1**	**2**	**3**	**4**
2i.	Become easily annoyed or irritated?	**0**	**1**	**2**	**3**	**4**
3i.	Got mixed up in your thinking when you have had to do things quickly?	**0**	**1**	**2**	**3**	**4**
4i.	Done things hastily or on impulse?	**0**	**1**	**2**	**3**	**4**
5i.	Been forgetful?	**0**	**1**	**2**	**3**	**4**
6i.	Found things getting on your nerves and wearing you out?	**0**	**1**	**2**	**3**	**4**
7i.	Become easily tired?	**0**	**1**	**2**	**3**	**4**
8i.	Become hot / flushed in the face for no apparent reason?	**0**	**1**	**2**	**3**	**4**
9i.	Had difficulty in falling or staying asleep	**0**	**1**	**2**	**3**	**4**
10i.	Found your feelings easily hurt?	**0**	**1**	**2**	**3**	**4**
11i.	Found it hard to make up your mind?	**0**	**1**	**2**	**3**	**4**
12i.	Had to clear your throat for no apparent reason?	**0**	**1**	**2**	**3**	**4**

	J	**PLEASE RATE THE DEGREE OF YOUR AGREEMENT WITH EACH OF THE FOLLOWING STATEMENTS ABOUT YOUR LIFE. PLEASE CIRCLE/TICK ONE CHOICE FOR EACH QUESTION.**							
			Strongly disagree	**Disagree**	**Slightly disagree**	**Neither agree nor disagree**	**Slightly agree**	**Agree**	**Strongly agree**
1j.		In most ways, my life is close to my ideal.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2j.		The conditions of my life are excellent.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3j.		I am satisfied with my life.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4j.		So far, I have gotten the important things I want in life.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5j.		If I could live my life over, I would change almost nothing.	**1**	**2**	**3**	**4**	**5**	**6**	**7**

PART 6: ABOUT YOU				
	Name:			
	Age		Sex (Male/Female)	
	Address for correspondence:			
	Your occupation:			
	Company:			
	Telephone No:			
	E-mail:			

(Having your contact information would be useful especially <u>for payment and follow-up purposes</u>.)

Marital Status

Single ☐ Married ☐ Widowed ☐ Divorced ☐

Do you have children living at home? ☐ Yes ☐ No

Your education level (Tick the highest level completed)

Primary school	☐	Undergraduate degree	☐
Secondary school	☐	Postgraduate degree	☐
Diploma	☐	Other: _______________	☐

PLEASE WRITE IN THE BOX BELOW TO MAKE ANY OTHER COMMENTS.

Thank you for your time and cooperation in completing this questionnaire.
Your responses are greatly appreciated.