

Research Needs to Inspire Future Research Efforts



By Michelle DeRobertis, Christopher Ferrell and Richard W. Lee

This article highlights several recent research projects that Transportation Choices principals have conducted. We encourage you to read the full reports for the analysis and conclusions. Below, we focus on the future research needs that these research efforts revealed. We publish them here in this first issue of the WTPP relaunch in the hope that it sparks the interest of the sustainable transportation community to either develop and conduct research in these particular areas or point us to past research that we may have missed that covers these topics. It is also hoped that the ideas presented below provide inspiration at many levels of discourse and research including Ph.D. and Masters theses, government-funded research, and city policymakers and staff who implement new policies and practices and experiment in “real time”. Please let us know if you have been inspired by one of the ideas below and how you have advanced it, either through further study or in practice.

The reports are presented in the following order:

- **City Best Practices to Improve Transit Operations and Safety.** Mineta Transportation Institute. 2021.
- **Characteristics of Effective Metropolitan Areawide Public Transit: A Comparison of European, Canadian, and Australian Case Studies.** Mineta Transportation Institute. 2020.
- **Analysis of the Benefits of Green Streets.** 2020. Mineta Transportation Institute.
- **Effective Employer Travel Demand Management (TDM) Today.** Unpublished research. 2018.
- **The Potential for Using Loyalty Rewards and Incentives Programs to Encourage Transit Ridership and Regional Transportation and Land Use Integration.** Christopher E. Ferrell, Ph.D., San Jose, CA: Mineta Transportation Institute. 2019.
- **Towards an Assessment of Livability In The ZTL: Reversing The Tragedy of The Commons of The Historic City Center; The Case Study of Brescia.** Michelle DeRobertis. Ph.D. Dissertation, University of Brescia Italy. 2019.

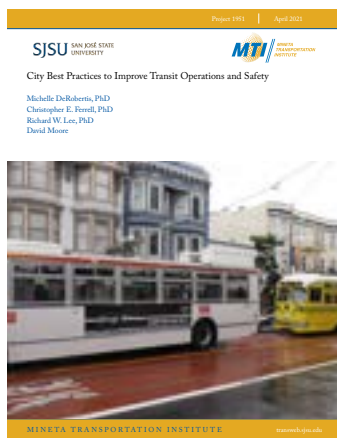
City Best Practices to Improve Transit Operations and Safety. MTI Report 21-09.

Mineta Transportation Institute,
San Jose State University, 2021.

<https://transweb.sjsu.edu/research/1951-City-Best-Practices-Improve-Transit-Operations-Safety>

Research purpose: To identify key policies and practices that help (or hinder) surface public transit that are outside the purview of the transit agency but within the

purview of cities and other local governments. This work identified specific policies and practices that local governments and other roadway owners can implement to improve public transportation given their control over the streets, intersections and sidewalks used by transit vehicles and transit passengers.



Abstract: Public, fixed-route transit services most commonly operate on public streets. In addition, transit passengers must use sidewalks to access transit stops and stations. However, streets and sidewalks are under the jurisdiction of municipalities, not transit agencies. Various municipal policies, practices, and decisions affect transit operations, rider convenience, and passenger safety. Thus, these government entities have an important influence over the quality, safety, and convenience of transit services in their jurisdictions. This research identified municipal policies and practices that affect public transport providers' ability to deliver transit services. The researchers used a comprehensive literature review, interviews and discussions with five local transit agencies in the U.S., input from five public transportation experts and from discussions with staff from five California cities. The city policies and practices identified fall into the following five categories: infrastructure for buses, including bus lanes, signal treatments, curbside access; infrastructure for riders

when walking to, bicycling to, and waiting at transit stops and stations; internal transportation planning policies and practices; land development review policies; and regional and metropolitan planning organization (MPO) issues. The understanding, acknowledgement, and implementation of policies and practices identified in this report can help municipalities proactively work with local transit providers to more efficiently and effectively operate transit service and improve passenger comfort and safety on city streets

Future Research Needs: While the primary goal of the research was to develop a list of best practices that help transit operations and passengers, it became evident that it might be more useful if the recommendations were prioritized for different contexts. This research also uncovered several related issues that merit further study. Thus, further research is recommended in five key areas:

1. Research to Refine the Master List of Recommended Practices

While some basic elements are the same across all cities, there are nuances depending on city size and context. Thus, recommended practices for creating transit-friendly cities may differ for cities of different sizes, economic conditions, and climate conditions. A large, transit-dependent city in a cold-weather climate requires substantial resources for snow removal over a large area to maintain lifeline transit services throughout the year, while a small city in the sun belt will require none. For this reason, it would be useful to develop different lists of best practices for different contexts as well as to develop a short, "must have" list. Focused research is needed to determine best practices for a variety of city contexts, to:

- Identify a short list of the most important impactful practices that would apply to all contexts. These would consist of those practices that result in the biggest improvements to transit, since the policies and practices are not of equal effectiveness. Research is needed to differentiate between the more significant and the more marginal practices.
- Identify and differentiate between practices that are more appropriate for small rural towns, for medium-sized cities, for large cities, and for suburban contexts.
- Identify which practices are appropriate for a transit agency that is a department of a single city versus a separate agency which serves multiple cities.
- While not always obvious, the needs and requirements



of building a transit-friendly city require frequent assessment of these city activities with respect to the city's vision for its future. A city that aspires to develop from a commuter suburb into a high-density employment hub will likely undertake different practices at all levels of government to support these goals than one that seeks to maintain its low-density, suburban character. Research that identifies different transit-supportive practices for cities aspiring to a variety of future development visions would help make implementation and coordination more effective.

2. Surveys to Determine the State of the Practice

Surveys of cities and transit agencies would be useful to determine not only the state of the practice but to determine which are considered key policies for various contexts. Suggestions include:

- Survey of U.S. transit agencies to determine which practices they consider to be the most impactful to their operations; stratify results by transit agency size, city size and context.
- Survey of cities to determine what they consider to be the best practices identified; stratify results by city size and type of transit agency, i.e., city-owned versus special district.
- Survey of cities to compare practices between cities with and without their own transit agency as a city department. This research could also investigate the relative prevalence of the “us versus them” relationship between the two categories of cities.

3. Development of a Best Practices Handbook

A handbook of guidelines for municipalities and transit agencies that describes when, where and how to use the policies and practices identified in this research would be very useful. It could include design illustrations and dimensions, as well as describe typical applications. For example, it could describe:

- Bus stop dimensions for expected volumes of buses and bus type (regular, articulated, etc.).
- Passenger amenities at bus stops by expected passenger volumes.
- Under what conditions (land use, traffic levels, street type) certain infrastructure is appropriate (e.g., bulbouts, transit boarding islands, TSP, bus-only lanes).

4. Institutionalization

This research identified a variety of policies and practices on the part of multiple city departments to successfully

support transit operations within a city's jurisdiction. Each of these functions and tasks deserves focused research attention. The research revealed that the actual mechanism for how transit-friendly policies or practices are carried out by individual departments is very important, but that there is no single way to do it. Cities used a variety of strategies to institutionalize their policies and practices including city ordinances, corridor plans, complete streets policies, departmental policies. Often there was no written policy at all, just legacy practice. Additional research would be very helpful in revealing the array of approaches—and the most effective approaches—for ensuring that the policies are implemented. Additional research is recommended for the following in particular:

- Determine which institutional strategies are most suitable for specific practices:
- for example, city ordinance versus area-wide plans versus adopted design standards versus departmental policies.
- Identify best practices for coordinating transit agencies and city functions across the spectrum of city operations and departments: This would identify options and strategies for encouraging inter-departmental collaboration and coordination for improving transit.
- It may first need to explore the questions, “Why are there coordination issues between cities and transit operators?” and “Are there process reforms that could help achieve better cooperation on the part of cities to implement policies and practices that help transit providers?”
- Determine state of the practice regarding whether and how cities are directing developer fees to fund public transit: This would also investigate whether or not other cities might benefit from the improvements.
- Opportunities and constraints for a regional transit benefit district: This would be similar to a city benefit district or Pro-Rata Share District (PSD) but the funds would go to the regional transit provider, and would come from all cities who would benefit from improved transit.

5. Mutual Adoption of Transit-Related Guidelines

Many transit agencies have developed written internal guidelines and some have even published documents intended for the cities they serve. It is unknown, however, how many cities have indeed adopted city guidelines that correspond with those of the (outside) transit agency. Two potential research projects are:

- Research to determine which cities have adopted their transit agencies' guidelines. Issues include curbside bus stop design, bus bulb-outs, passenger waiting areas at bus stops, signal and intersection design issues, zoning density, etc.
- AC Transit Guidelines Adoption Case Studies: Research to determine how many of the thirteen cities served by AC Transit adopted any of the design guidelines described in AC Transit's guidelines published in 2004.

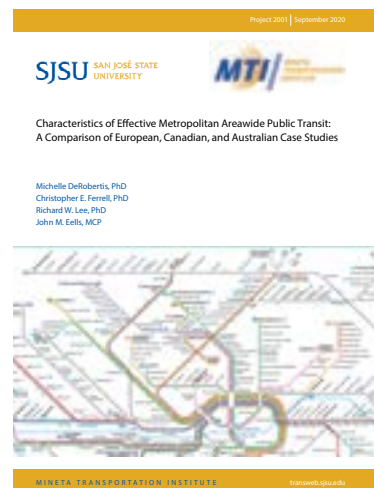
Characteristics of Effective Metropolitan Areawide Public Transit: A Comparison of European, Canadian, and Australian Case Studies. MTI Report 20-42. Mineta Transportation Institute, San Jose State University, 2020. <https://transweb.sjsu.edu/research/2001-Effective-Metropolitan-Transit>

Research purpose: To identify the replicable factors in metropolitan public transportation that make transit an effective competitor to the private motor vehicle.

Abstract: This research project investigates the replicable characteristics, policies, and practices of successful metropolitan areawide public transportation networks that contribute to high usage and make transit an effective competitor to the private motor vehicle. The research method involves the qualitative and quantitative analysis of ten international (non-U.S.) case studies. The principal methods employed were web-based research and data collection, as well as telephone interviews with transit agency staff or regional planners as needed. The case studies were limited to developed western countries with similar metropolitan conditions to those in the United States.

This research focuses on key characteristics of highly effective regional transit systems from the perspective of the metropolitan area, not the individual transit operators. These characteristics fall within three broad categories: the setting of the metropolitan area; the customer-apparent transit service features; and the behind-the-scenes or institutional characteristics.

Key findings are: (1) all ten case studies have a metropolitan areawide regional transit coordinator



(RTC); (2) RTCs yield benefits in terms of ridership and operating efficiencies that are discernable from the effects of high transit funding and subsidies; (3) all case studies had some degree of fare integration, and most had complete regionwide fare integration; and (4) transit service was

frequent, abundant, and affordable in all cases. The features of excellent regionwide transit systems that have been identified in this research can be applied to U.S. metropolitan areas with multiple players, yielding effective, efficient, and high mode share transit at the regional level. The research can help U.S. policy makers and planners begin to improve the appropriate aspects of their own regional transit systems, including by improving coordination and organizational structures.

Future Research Needs: The findings of this study suggest the following areas for complementary research.

1. A comparison of specific U.S. metropolitan area transit networks with the findings of this research, particularly with respect to the coordination of agencies within the same metropolitan area and institution of single unified fare policies across operators.
2. An analysis of the relation between regional transit coordination and regional Governance.
3. Case studies of successful regional governance models particularly in regions with rings of suburban communities surrounding medium and large cities.
4. Identification of the key elements that Regional Transit Coordinators need in their authorization that give them both the mandate and the tools to be effective.
5. Presence and density of several layers of rail transit (urban and regional) in metropolitan areas with excellent transit (e.g., kilometers of rail lines,



reflecting spatial coverage, and vehicle-kilometers, reflecting amount of service per square kilometer and per capita), and the role of complementary versus redundant service.

6. Comparison of bus-only lane networks of various metropolitan areas with excellent public transit.
7. Cost savings that accrue from coordination endeavors such as savings from procurement of rolling stocks and single websites for marketing and travel planning.
8. Travel time comparison of transit trips versus automobile trips in various metropolitan areas.
9. Travel time comparison of total public transit trips, including transfers and waiting times, in areas with excellent public transit.
10. Comparison of investment in rail transit into expanding and extending rail lines: light rail, metro, and suburban rail. This should consider both absolute miles and miles normalized per population and per square kilometer.
11. Sources of public funding for transit systems in areas with excellent public transit.
12. In areas with complete fare integration, especially those areas that also have multiple system owners, what are the policies for allocating fare revenue among the different modes and systems?
13. Comparisons of when and how rural and low-density areas have public transit, including regional public transit, in various western countries.
14. Techniques and management strategies to ensure schedule adherence, particularly for timed transfer connections. Are there differences when there is consolidation versus coordination?
15. Analysis of transit driver pay and performance bonuses as well as operations staffing levels in areas with excellent public transit. How do these features relate to schedule adherence?
16. For areas with multiple transit system owners, analysis of how labor rules and other management issues are reconciled among the different transit system owners under Regional Transit Coordination.
17. Case studies of win/win situations: where improved transit labor rules also improve transit reliability and

customer experience (e.g., adequately staffing real-time monitoring and dispatching, bonuses for driving the most challenging routes, bonuses for beginning scheduled routes on time after taking rest breaks).

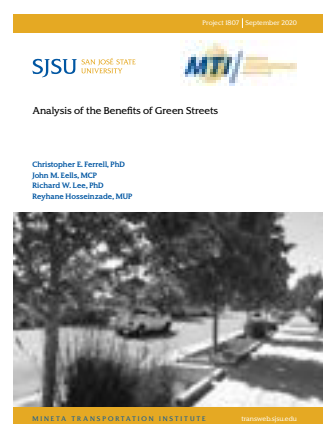
18. Ensuring the viability of public transit in the wake of COVID-19 and the ramifications for transit agencies that may stem from the pandemic.

Analysis of the Benefits of Green Streets. MTI Report 20-32. Mineta Transportation Institute, San Jose State University, 2020. <https://transweb.sjsu.edu/research/1807-Green-Streets>

Research purpose: To identify available, “off-the-shelf”, analysis tools that the California Department of Transportation (Caltrans) can use in their planning, engineering, and administrative processes to evaluate the benefits of Green Streets infrastructure.

Abstract: Green streets, as defined by the Environmental Protection Agency, are streets that incorporate different kinds of vegetation and permeable surfaces “...to slow, filter, and cleanse storm water run-off from impermeable surfaces.” Unlike

traditional streets, green streets retain runoff at the source rather than discharging runoff off-site. Green streets offer many other potential benefits that include improving water quality, absorbing carbon (sequestration), and reducing urban heat island effects. This report summarizes: (1) the research team’s analysis of 14 tools



calculating green streets benefits; and (2) the results of applying the two most promising calculators to a select group of green streets case studies. The report presents the results of the case study analyses, with an emphasis on carbon sequestration benefits estimated using the i-Tree Design calculator, and improvements to pedestrian levels of service estimated using a Highway Capacity Manual (HCM)-based (the “Landis”) method.

Trees absorb carbon dioxide and other pollutants from the air, reducing the costs of future climate change mitigations and medical care. Key findings obtained using i-Tree Design suggest that the monetary value (CO₂ and air quality) of planting street trees is small but significant, with total estimated benefits from street trees on seven case study sites ranging from a low of \$1,466 to a high of \$9,420 over a 20-year period. On a per tree basis, the lowest benefits come from site 3A (Cherry Avenue in San Jose) with \$10 per tree, and the highest come from site 1A (San Pablo Avenue in El Cerrito) at \$175 per tree.

While the Landis PLOS method accounts for the benefits of short street tree spacings (i.e., a high number of trees) and of having a continuous biostrip or planter strip serving as a pedestrian buffer, the method does not appear to be sensitive to tree spacings, though it is very sensitive to buffers. Therefore, the importance of having a biostrip or planter strip buffer between the sidewalk and street traffic is also reflected in the PLOS findings in this study. While the measurable benefits of a handful of street trees may seem small, this study suggests that using i-Tree Design to add together the trees planted by local and state agencies has the potential to provide a compelling picture of the carbon sequestration benefits across California. Similarly, the use of Highway Capacity Manual (HCM)-based pedestrian level of service methods by transportation professionals can bring significant gains in the appreciation of green streets' benefits.

Future Research Needs:

- Identify the metrics, methods, and models that are needed to capture the full range of potential green streets infrastructure benefits.
- Create a unified tool that is capable of measuring these benefits on the geographic scale(s) needed by local, state, and federal transportation agencies in their planning, engineering, and administrative processes.

Effective Employer Travel Demand Management (TDM) Today

(unpublished research)

Research purpose: To answer the question: Given social and economic changes since the Great Recession, what does an effective employer-based travel demand management look like?

Abstract: Through a literature review and case studies, a research team attempted to identify best TDM programs at a range of employment centers circa 2015. The range of employment centers included corporate work sites, multi-firm office parks, commercial districts, and educational/institutional campuses. While the study was terminated due to a shift in priorities by the sponsor, initial findings determined that tech companies in the San Francisco Bay Area had robust multi-faceted TDM programs. Moreover, elements of these programs had potential for transfer, e.g. tailored ridematching through smartphone applications.

Future Research Needs:

1. Case studies of successful employer-based TDM programs under post-COVID-19 pandemic conditions for different types of employment centers (e.g., single firm/multi-firm, corporate educational/institutional campuses, etc.) in both urban and suburban areas, in a variety of national settings.
2. Through case-studies, determine important TDM program elements, with an emphasis on transferable elements.
3. Quantitative and qualitative data collection measuring outcomes of post-pandemic TDM programs (e.g. mode split/mode shift, cordon counts, program participation statistics, etc.).



Typical ZTL sign, Italy. Photo by Michelle DeRobertis

“The Potential for Using Loyalty Rewards and Incentives Programs to Encourage Transit Ridership and Regional Transportation and Land Use Integration.” Christopher E. Ferrell, Ph.D., San Jose, CA: Mineta Transportation Institute. 2019.

Research purpose: To evaluate the potential for using transit smart cards as a tool for increasing transit ridership, retail sales in transit-oriented developments (TODs) and eventually, increasing retail development in TODs.

Abstract: This report provides a compilation and analysis of the literature, and of three case studies, on the potential for rewards- and incentives-based programs in the North American transit industry. The initial inspiration for this research came from the idea that transit smart cards could be used as a tool for increasing transit ridership, increasing retail sales in transit-oriented developments (TODs) and eventually, increasing opportunities for retail development in TODs.

This might work by expanding the scope and capabilities of transit smart cards to include “customer loyalty rewards” capabilities, thereby increasing patronage of retail businesses located in TODs. Instead of providing separate loyalty rewards for each store, or chain of stores, such cards would provide loyalty rewards—in several possible forms, including free transit ride credits, cash rewards, retail purchase discounts, sweepstakes rewards—to all transit riders who patronize TOD retail businesses. Additional rewards could also be given to transit riders who live, work, and shop in TODs, and even to riders who take transit for specific shopping trips in TODs. In this way, smart cards and transit loyalty programs could become not only useful tools for increasing transit ridership, but also tools for targeted economic development of individual TODs, a means to increase economic opportunities and equity for low-income residents and shoppers in inner-city commercial zones, and in their most fully-realized expression, as tools for regional planners to concentrate retail, services and housing in priority development areas consistent with smart-growth planning principles.

From this initial inspiration, a plan was developed to gather research literature on the relationships between smart cards and transit ridership, between transit ridership and retail activities, and between retail sales and retail development in TODs. In the process of this literature search, examples were identified of programs that have been implemented in three North American transit agencies. Case study profiles were developed from a combination of source publication materials, traditional and electronic media, and telephone interviews with program representatives. Three topics discussed in the literature are central to this research (sometimes referred to here as “the benefits”): 1) the best economic development practices and outcomes for retail; 2) the ridership effects of transit smart card programs; and 3) the effects of incentives programs, membership and other rewards programs on retail and travel behavior. An overview of the literature in these topic areas follows, highlighting subjects that are either relatively new or not as well-known in the transportation planning community. This overview and analysis of the literature is followed by summaries of three case studies of transit rewards and/or loyalty programs in North America: Montreal, Canada; Minneapolis/ St. Paul, Minnesota; and the San Francisco Bay Area, California.



Multimodal Public Transit Tickets
Photo: Michelle DeRobertis

Future Research Needs:

1. More practice-driven research and experimentation is needed on transit rider rewards and loyalty programs. In particular, research to identify the best practices for the ownership, management and administration of loyalty rewards programs would be helpful to determine the degree public sector administration, contracting-out, or outright privatization yields the most effective and sustainable outcomes.
2. Market segment analysis is needed to understand the most effective rewards for the variety of transit riders according to socio-economic characteristics, lifestyle preferences, and corresponding transit system capabilities (both existing and future).

“Towards An Assessment Of Livability In The ZTL: Reversing The Tragedy Of The Commons Of The Historic City Center; The Case Study Of Brescia.” Michelle DeRobertis, Ph.D. Dissertation, University of Brescia Italy. March 2019.

Research purpose: To quantitatively and qualitatively measure the improvement in livability due to the implementation of traffic limited zones (ZTLs) in the historic city center of Brescia, Italy.



Abstract: Traffic-Limited Zones (ZTL) in Italy have been used for decades to improve the ambiance of historic city centers from the onslaught of motor vehicles, their noise and pollution. This thesis evaluates the effectiveness of Traffic-Limited Zones in improving the ambiance and the quality of life for both residents and visitors

to the historic city center of Brescia. Since there is no single standard for defining “livability” and “quality of life”, especially for city centers, the methodology included a review of research by others on indicators

for measuring city livability. Many potential indicators were identified and 12 livability-ambiance indicators were selected to evaluate whether and how ZTL have improved livability in the city center. The methodology also included an opinion survey of both residents and visitors to the city center.

The City of Brescia was used as the case study to analyze these indicators to determine whether livability has improved in the city center since ZTLs were implemented. Although impossible to isolate only the effect of the ZTL, it was found that all indicators showed an improvement in livability. These indicators may also be useful to evaluate the ZTL of other cities and to evaluate other strategies and interventions that reduce traffic volumes.

Key findings include:

- Not only ZTL but also the number of pedestrian streets has increased. Over 2 km of pedestrian streets were initially ZTLs, demonstrating that ZTLs are a first step to the implementation of a pedestrian street.
- Traffic volumes decreased not only on ZTL streets but in the entire city center.
- After the implementation of the ZTL, both the number of collisions and collision rates declined proportionately more than that of the reduced traffic volumes; this is also true for the entire city center not just ZTL streets.
- Families are returning to the city center and those who live in the ZTL rate the quality of life at least as good or better as those who live outside the city center or outside of the city of Brescia.
- Only 1/3 of ZTL residents would reduce either the hours or the extent of the ZTL.
- Within the city center, there is more outdoor seating at bars and restaurants on streets with less traffic; pedestrian streets/ piazzas have the most, followed by ZTL streets, and open streets have the least.

Future Research Needs:

This research raised far more questions than it answered. Many avenues of future research are recommended. These have been organized into five main themes.

1. Further research on the history and evolution of ZTL.
2. Opinion survey of ZTL benefits – qualitative assessment
3. Objective measures of ZTL impacts and benefits - quantitative assessment
4. Development of better analytical tools to assess livability
5. Related planning issues



1. ZTL History and Current Extension in Italy

The review of the literature revealed conflicting information regarding where and when ZTL originated in Italy. It also revealed that there exists a lack of knowledge as to which have had any evaluation of any kind. Furthermore there is no single definitive list of which cities currently have ZTL; the most complete information comes from two private websites.

A research effort to document the history and evolution of the ZTL in Italy would be warranted. One possible strategy to document not only the history but the current state of the practice would be to conduct a survey of existing cities with ZTL to determine not only the timing but also whether or not there have been unanticipated problems. If there have been unanticipated benefits. The findings of such a nationwide survey could help city officials in cities with ZTL in designing the extent and hours of future expansions of ZTLs. The findings could also help other cities that do not have ZTL, both within and outside of Italy, decide whether and how to implement ZTL or similar strategies.

For example this research has determined that the extent of the ZTL in Brescia was rarely constant for more than a few years for most of its 45-year history. The size of the ZTL mostly continued to expand until it reached a peak in 2003 of 22 km, then shrank a bit. It is not known if this type of growth for a ZTL over 40 years is typical for other cities in Italy or if it is a uniquely Brescian experience. For example, Bologna also began with a smaller ZTL but then it soon expanded to be essentially within the old city wall, and the ZTL area has remained fairly constant for decades. Research on the growth of the ZTL in other medium to large Italian cities and how the current ZTL extent compares to the boundaries of the centro storico and /or old city walls, if any, would be interesting from the perspective of urban planning.

2 Statistically Significant Opinion Survey

It would be very informative to have a statistically significant survey of the residents and visitors to a ZTL. Questions about livability aspects that are difficult to quantify would be particularly useful, such as bothersome traffic fumes and noise and general attractiveness and livability. Questions on opinions of the disadvantages as well as advantages of living and visiting the ZTL would be useful as well. Any future survey

should clearly ask the nonresidents of the ZTL if they think the ambiance of streets have improved since the ZTL restrictions have been implemented and how. This one question was not asked as part of this research and therefore this perspective is missing from our analysis.

Moreover, a survey that could truly assess opinions of both the before and after ZTL conditions within a short timeframe would be extremely valuable. For example, if a new ZTL is about to be implemented or if a ZTL is about to be significantly expanded, a survey before the new ZTL is implemented could assess what residents think about traffic noise and fumes presently, and this would be followed by an after survey. Alternatively, a survey could ask a question along the lines of Question 8 from this research: "If you lived here before it became a ZTL, have the following gotten better or worse?" This would be extremely useful to assess what people who live in ZTL and are old enough to remember prior conditions, think about the benefits and impacts of the ZTL.

A statistically significant survey of a single city could corroborate some of the findings of this research e.g. that traffic fumes and noise are less bothersome and that most people, both residents and nonresidents, would choose to keep the ZTL. But in addition, simultaneous surveys of multiple cities would be useful as well. Surveys of cities of different sizes would help to determine if there are differences in the opinions of the respondents between small, medium and large cities or between cities with many tourists versus cities with few tourists. However when comparing different cities, the selected cities should be similar in both the hours that the ZTL is in effect and the types of exemptions.

The purpose of these surveys would be to:

- help planners in cities with ZTL in designing the extent and hours of future expansions of ZTLs and also in how to ameliorate some of the perceived disadvantages.
- help other cities decide whether and how to implement ZTL or similar strategies.

3. Objective Measures of ZTL Impacts

- More research is needed on objective measures of how the ZTL has improved livability. There are numerous approaches, including:
- Before-after case studies to measure the benefits of ZTL (or other auto-restricting strategies).

- Comparison of ZTL historic city center to non-ZTL historic city center.
- Determine characteristics of a successful ZTL
- Comparison of ZTL to Other Strategies such as pedestrian-only streets, low emission zones, 30 km/hr zones, pie/cell zones, opposing one-way streets, barricades/cul de sacking, and pricing strategies such as congestion charges, cordon pricing, or road pricing.

4. Develop Better Tools to Measure the Benefits of Auto-restricting Strategies

The purpose of this research would be to develop better ways to measure the effects of strategies that restrict and reduce traffic volumes. These methods could apply to ZTLs as well as other strategies such as zone and collar, opposing one-way streets, and street barricades or blockages such as cul de sacking.

Specific criteria that need better tools are:

- measuring improved human health from less traffic exhaust.
- measuring annoyance from less traffic fumes.
- measuring annoyance from less traffic noise.
- measuring annoyance from less visual incursion.
- measuring attractiveness with objective indicators.

Also there may be merit in including some economic indicators but they would need to be carefully selected to ensure that they do not measure only the benefits to one socio-economic group.

5. Related Planning Issues

A few other ideas might be worthy of further evaluation. These are:

- **Role of the city center in facilitating social interactions.** The opinion survey revealed that the city center is an important social center not only for city center residents but also for residents of the whole city and even the province (Figure 8.7). This aspect is worthy of further investigation. Future surveys could ascertain the role of the city center for different age groups such as teenagers, young adults, families, and elderly. Another variable would be to determine the specific types of social engagement that the city center affords to different groups of people and how ZTL facilitates the provision of these types of interactions.



Piazza Loggia, Brescia as a meeting place.

Photo: Michelle DeRobertis

- **Where and how the location of outdoor seating is provided.** A lesson from this research with respect to outdoor seating is to account for the width of both the street and sidewalk since the sidewalk width and the presence of a parking lane affect whether or not there is even space to put outdoor seating (Figure 8.8). Thus future surveys should control for both these variables. These variables may also affect other future indicators that measure attractiveness. Future study could also determine under what conditions some sort of barrier between the tables and the traffic lane is provided.
- **Role of on-street parked cars in a city scape.** The literature revealed a few studies whose premise was that parked cars on the street contribute to the degradation of livability due to their adverse visual impacts. It is recognized that some studies in the U.S. have adopted the opposite point of view and in fact specifically recommend on-street parking as a benefit to pedestrians since they provide a buffer between the sidewalk and the moving lane of traffic (Novak, 2013). This is directly contrary to the concept of parked cars as an eyesore that diminish the ambiance of the setting as held by Buchanan and City of Brescia. An area of further research is to investigate which settings benefit from on-street parking and which areas are degraded by the presence such parking. Factors to consider in such future research could be the degree to which it is an historical setting, the speed of adjacent traffic, land use frontage, amount and type of pedestrians, functional classification of the road, width of the road, and building-to-building width. This research should also differentiate between Italian/European contexts and American/Canadian contexts.



*Traffic-limited zone in Moena, Trento, Italy.
Photo by Michelle DeRobertis*

- **Role of parking in attracting people to the city center.** This research would investigate the role of peripheral parking garages in attracting nonresidents to the city center, particularly city centers with traffic restrictions. This could address both the economic vitality of the city center as well as its role as a social gathering spot i.e. taking into account both shoppers and people who come to the city center and don't necessarily spend money but their presence serves to enhance the sense of vitality in the center. Are peripheral parking garages equally important for both groups of people?
- Another aspect of parking would be to investigate how important on-street parking is to the economic vitality of the retail sector in the city center, or is parking in a garage at the periphery sufficient? Many complain of the distance in walking if one cannot park on-street (both in a city center and suburban context). But this begs two or more questions:
 - 1) What are the odds of an on-street parking space being available in front of one's destination? How often is one able to park on the same block let alone in front of one's destination? Indeed, how far does the average shopper walk when going to a business in those locations when there is on-street parking?
 - 2) How do these walking distances in city centers with traffic restrictions and peripheral parking garages compare to those walked at suburban shopping malls? One can rarely park in front of one's destination in this latter context either.

This parking research would also be useful to the USA context since most American shopkeepers would also insist that they need on-street parking in front of their store. But it is unknown what percentage of their sales actually come from someone who parked within 10 to

50 meters of their store. And even if they did, it would be useful to know how many times they circled the block in order to find said parking place.

- Correlate ZTL Research to Buchanan's Environmental Capacity Methodology. Appendix 1 of *Traffic in Towns* determined an upper limit of traffic volumes for residential streets, i.e. environmental capacity. The methodology was developed from the observations of 50 residential streets which were analyzed to determine the ADT at which the delay for pedestrians wishing to cross the street becomes unacceptable. From these observations, nine nomographs were developed depicting the environmental capacity, based on three variables: roadway width, "vulnerability" of the pedestrians (i.e. their age and abilities), and "protection" for pedestrians (street design and built environment aspects). It would be an interesting intellectual exercise to compare the ADT of ZTL streets to these nine nomographs of environmental capacity.

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