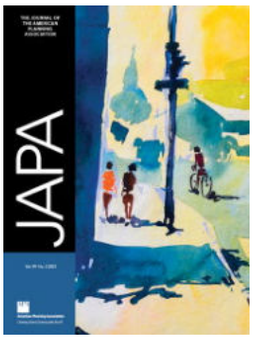

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# An Empirical Analysis of the Link Between Built Environment and Safety in Chicago's Transit Station Areas

Ahoura Zandiatashbar Agustina Laurito


## ABSTRACT

**Problem, research strategy, and findings:** Considering that safety is a key environmental factor that promotes health, understanding the relationship between built environment features around transit station areas and crime may shed light on how to foster healthy communities. Yet, there is limited work that has examined how the combination of different built environment features around transit correlate with different crimes. We addressed this issue in this study using data from Chicago (IL). First, we used cluster analysis to classify stations in Chicago in a spectrum from transit-oriented development (TOD) to transit-adjacent development (TAD) categories depending on their built environment characteristics: central business district (CBD)–TOD, TOD, hybrid, and TAD. Then, we identified the block groups that fell within a 1-mile network distance of each of these station areas and used propensity score matching to find adequate comparison block groups for them. Results from our analyses show that CBD station areas with the highest activity density, land use diversity, amenity richness, accessibility, and walkability (i.e., CBD–TOD) were the safest. In contrast, TOD areas with medium activity density and land use diversity but high amenity richness, walkability, and accessibility appeared to be the least safe. That said, low levels across these built environment features as found in TAD station areas also correlated with higher crime.

**Takeaway for practice:** These findings suggest the importance of balancing amenity richness and accessibility with density and land use diversity. Areas rich in amenities but with lower levels of land use diversity and density may attract crime victims and offenders while facilitating spaces in which the availability of eyes on the street or guardians is low. As such, these station areas may be poor promoters of healthy communities if high crime rates deter people from engaging in active mobility promoted by greater walkability, connectivity, and amenity richness.


**Keywords:** built environment, crime, healthy communities, safety, transit-oriented development

Development around public transit stations can have various impacts on communities. It can revitalize the neighborhood's economy through increased connectivity to jobs and other neighborhoods, and it can promote a less car-centric environment. Transit-oriented development (TOD), in addition to zoning changes, involves implementing street design changes to create active transportation-friendly environments as well as soft policy interventions (e.g., parking pricing) close to transit stations to promote active mobility. As such, TOD can be a planning tool that promotes health by encouraging physical activity but also through its potential relation with crime and safety.

On the one hand, large concentrations of people in and around transit stations may increase opportunities for criminal activity, provide cover for perpetrators, and facilitate an easy way to escape. TODs may also attract criminogenic land uses such as bars, restaurants, and liquor stores (Block & Block, 2000; Twinam, 2017). On the other hand, more people in the TOD area may contribute to keeping eyes on the street, deterring would-be criminals during times of highest activity (Billings et al., 2011; Paulsen, 2012; Zhang, 2016). TOD may also discourage land uses associated with higher rates of violent crime such as parking lots (Loukaitou-Sideris et al., 2002).

Although there is a rich literature that has examined the connection between transit and crime (Block &

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Block, 2000; Ihlanfeldt, 2003; Kooi, 2013; Loukaitou-Sideris, 1999; Phillips & Sandler, 2015; Ridgeway & MacDonald, 2017), with some exceptions, this work has focused on crime on transit itself (and along stations or bus stops) but has provided less insight into how the built environment around the station affects criminal activity. Similarly, outside of a few studies, the literature on land use and crime (Browning et al., 2010; Stucky & Ottensmann, 2009; Twinam, 2017; Wo, 2019; Zahnow, 2018) and street connectivity and crime (Beavon et al., 1994; Kim & Hipp, 2020, 2021) has not considered the role of public transit and how it may interact with these built environment characteristics. Existing literature has examined these factors in isolation from each other. Thus, it has shed little light into how the combination of these elements favored by TOD may relate to crime. In this study, we help address this gap. Given that crime is a key element of the active community environments framework (Doyle et al., 2006), our study helps understand how TOD, as a planning tool, may contribute to healthy communities through its association with crime.

Our study used data from Chicago (IL) and cluster analysis to classify train station areas into four types based on their activity density, land use diversity, amenity richness, e-bike use, transit accessibility, and street connectivity within a 1-mile network distance. Our TOD classification accounted for e-bike use because it facilitated last-mile trips to stations and generally increased accessibility to the station area.[1] We compared crime rates in block groups that fall within each of the station types. We used propensity score matching (PSM) to find comparison block groups that were similar on socioeconomic attributes but located in different station area types.

Briefly, we found differences in crime rates across station area types, confirming prior work that the built environment is an important correlate of violent and property crime. We also found that areas with very high density and land use diversity combined with very high amenity richness and accessibility had fewer crimes. However, lower activity density and land use diversity, while maintaining amenity richness and accessibility, correlated with more crime. Planners interested in how design features may promote health should consider the opposing forces that may be at play in some station areas. Features that may promote health through an active lifestyle such as high amenities, walkability, and accessibility may also contribute to more crime in environments with medium activity density and land use diversity.

## Literature Review

TOD is becoming a popular planning strategy in many cities. TODs are compact neighborhoods centered around transit (Lund, 2006). A key feature of TODs is the existence of efficient land use diversity (Kamruzzaman et al., 2014; Renne & Ewing, 2013), density, street connectivity, and walkability. TODs should encourage residents to rely on public transit, drive less, and walk more. These are key features of TOD that directly link this urban development strategy to the active community environment framework, which centers on identifying key environmental elements that may correlate with health (Aytur et al., 2007; Doyle et al., 2006).

### *Healthy Communities*

The active community environment framework has suggested that more walkable and safer areas would encourage physical activity and improve health outcomes such as body mass index (BMI), thereby improving community health (Doyle et al., 2006). Prior work has shown more physical activity in areas that are more walkable, have shorter streets, and have more street intersections (Ewing et al., 2003, 2014). Density seems to play a different role. A study conducted in the United States at the metropolitan statistical area level showed better individual health in metropolitan statistical areas that are more walkable but less dense (Kelly-Schwartz et al., 2004). Doyle et al. (2006) hypothesized that urban density may act as a stressor and thus negatively correlate with health.

Living in unsafe environments has been linked with poor self-reported and cardiovascular health (Browning et al., 2012; Hale et al., 2010). Lack of safety may adversely affect health through increased stress and associated responses such as difficulty sleeping (Hale et al., 2010, 2019; Hill et al., 2016). Further, persons living in high-crime neighborhoods may be less likely to engage in physical activity (walking, running, or exercising), which can increase the likelihood of obesity and high BMI. Evidence of the effect of crime on physical activity has pointed to a negative relationship (Yu & Lippert, 2016). It is less clear how these reductions in physical activity relate to BMI (Yu & Lippert, 2016). In sum, existing literature has found that built environment features and neighborhood crime correlate with various health outcomes, suggesting that TOD could contribute to healthy communities directly through its built environment characteristics or indirectly through its effect on crime and safety, which was the focus of our study.

### *Transit-Oriented Development*

Most research on TOD has examined important issues such as the decision to live in a TOD area (Lund, 2006), parking availability and car ownership (Chatman, 2013; Ewing et al., 2019), commuting choices of TOD residents

(Thrun et al., 2016), and the relation between TOD and property values (Kay et al., 2014). Little recent work has investigated the association between TOD and crime.

This is surprising because the idea that the built environment can influence crime has a long history in urban planning, beginning with the work of Jane Jacobs (1961) and the crime prevention through environmental design literature that followed (Newman, 1972). From this perspective, built environment features associated with TOD may relate to crime in two main ways. On the one hand, density, mixed land use, and the concentration of people in and around transit stations could provide opportunities for criminal activities by increasing the number of potential victims and reducing the number of guardians through weaker social control (Brantingham & Brantingham, 1993; Cohen & Felson, 1979; Taylor et al., 1995). Further, high street connectivity and the availability of transit provide perpetrators with the means to hide and escape (Ihlanfeldt, 2003; Kim & Hipp, 2021; Loukaitou-Sideris et al., 2002). In short, TOD may contribute to creating areas that become crime attractors as well as crime generators (Brantingham & Brantingham, 1993; Irvin-Erickson & La Vigne, 2015).

On the other hand, TOD features may contribute to keeping eyes on the street, deterring would-be offenders from committing crimes by increasing the number of potential witnesses (Billings et al., 2011; Jacobs 1961; Paulsen 2012; Zhang, 2016). In an early study, Block and Block (2000) showed this may be the case. They analyzed data from Chicago and the Bronx (NY) showing that most robberies happened a few blocks away from transit stations in places they called *critical intensity areas*. These are areas with enough potential victims and means of escape for perpetrators but few witnesses (Block & Block, 2000). Transit stations and the surrounding development associated with TODs may also include more police presence and other security measures that may deter crime (Braga et al., 2014; MacDonald et al., 2016). Further, if TODs also contribute to a fewer vacant lots and parking lots, we could also see less crime (Loukaitou-Sideris et al., 2002; Moyer et al., 2019).

Existing literature has examined the link between specific built environment features and crime. Overall, research focused on land use has supported the eyes on the street perspective, showing that increases in land use diversity are linked with lower crimes. Browning et al. (2010) found evidence that mixed commercial and residential uses correlated with lower rates of homicides and assaults but not robberies. Twinam (2017) used a stronger research design to isolate causal effects and found that more commercial activity increased assaults and robberies, but that mixed uses helped to lower crime. That said, land uses such as bars, restaurants, liquor stores, and schools increase crime (Block & Block, 2000; Twinam, 2017; Zahnow, 2018), as do parking lots (Loukaitou-Sideris et al., 2002). In sum, to the extent that TOD contributes to land use diversity, density, and the reduction of parking lots, violent crime could be lower through increasing eyes on the street as a mechanism of social control. However, this relationship may be moderated by the presence of criminogenic facilities, including the station itself. Regarding population density, Loukaitou-Sideris et al. (2002) found that property crimes were more prevalent in neighborhoods with higher population density, whereas violent crimes happened in busier stations.

Research on street connectivity and walkability is mixed. Some studies found that more connected streets are associated with higher crime (robberies, burglaries; Davies & Johnson, 2015; Summers & Johnson, 2017), though street network complexity and traffic flow may be associated with less crime (Beavon et al., 1994; Birks & Davies, 2017). In a recent study, Kim and Hipp (2020) found that, at lower levels, more street activity and connectivity correlated with more crime, but this was no longer the case at higher levels. Other work has supported this nonlinear relationship (Birks & Davies, 2017). Similar mixed findings have emerged from the walkability literature. Cowen et al. (2019) used data from Miami–Dade (FL) and found a positive relationship between walkability and violent crime (aggravated assaults). In contrast, Dong (2017a) found a positive relationship between walkability and burglaries but not robberies. Similarly, Gilderbloom et al. (2015) found that walkability (measured by the Walk Score) was associated with lower crime. This is important because the Walk Score captures distance to various neighborhood amenities and is the same measure we used in this study.

Further, many cities in the United States have experienced the growth of micro-mobility involving bicycle sharing (e-bikes) and e-scooters. These new modes of transportation may facilitate last-mile trips and increase accessibility to the station area (Tuncer et al., 2020) and sustainability (Abduljabbar et al., 2021). Thus, micro-mobility in and around a transit station could influence the relationship between station-area features and crime. For example, the existence of micro-mobility around a station could facilitate crime through access to the station for potential victims and offenders. Conversely, these technologies may contribute to lowering crime by increasing social control. Most current work on micro-mobility has focused on the management, common uses, distance traveled, and pedestrian safety (Espinoza et al., 2019; Gössling, 2020; Oeschger et al., 2020; Tuncer et al., 2020), but so far less work has investigated their connection with crime. A recent study examined station area characteristics and micro-mobility in the Bay Area (CA), finding that Bay Area Rapid Transit stations with higher

crimes discouraged the use of micro-mobility, whereas those with more amenities such as coffee shops increased it (Ferguson & Sanguinetti, 2021). That said, we did not investigate whether the presence of micro-mobility in and around transit stations contributed (or not) to criminal activity. Our study is one of the first to incorporate micro-mobility as part of the station-area environment to examine the relationship between station area features and crime.

This review of the literature suggests that some of TOD features such as mixed land uses and fewer parking lots may negatively correlate with crime (violent and property crime), though the presence of criminogenic facilities may moderate this relationship. Higher population density may contribute to higher crime rates if it increases the number of potential victims and makes social control more difficult. As for walkability and higher street connectivity, predictions are mixed. More street complexity and food traffic may help lower crime (property and violent crime) in walkable and amenity-rich areas by increasing eyes on the street, though evidence has suggested the opposite might also be true. The same prediction may apply to micro-mobility because it takes advantage of street network configurations as well as the presence of amenities, but evidence of the relationship with crime has been limited. Overall, whether and to what extent different combinations of these features within station area types relate to crime is the empirical question that we sought to answer in this study.

## Study Area

Chicago provided a good context to investigate the relationship between TOD and crime due to its extensive transit system, the existence of city ordinances that promote TODs, high crime rates, and wide data availability. As shown in Figure 1, Chicago has an extensive rail system (the "L") that connects city neighborhoods and the suburbs. In 2019, the L operated along 144 stations and eight routes. It is administered and operated by the Chicago Transit Authority, and as of 2017 it was the second largest transit system in the United States.

Chicago has also taken steps to promote TODs. In 2013 the city approved an ordinance that included zoning changes establishing minimum lot areas, increasing floor–area ratios, reducing parking by 50%, and increasing building height around station areas. A new ordinance in 2015 expanded the size of TOD zones from 600 to 1,320 ft or from 1,200 to 2,640 ft on a pedestrian street, eliminated parking, and added incentives for affordable housing (City of Chicago, Office of the City Clerk, 2013, 2015). These policy changes allowed the opportunity to identify different station types, including those that included TOD elements among Chicago's many transit stations.

## Data and Methods

### *Data Sources and Measures*

We used data from various sources, including crime data from the Chicago Police Department available on the Chicago Open Data Portal (Chicago Crime, 2020). The data included the type and date of the crime and latitude and longitude, allowing us to geocode crimes to block groups.[2] We focused on crimes that happened throughout 2019, and we categorized crimes following the Uniform Crime Report (UCR). The UCR classifies homicides, aggravated assaults, robberies, and rape as violent crimes. Separately, we identified burglaries (a property crime in the UCR) and thefts (also property crimes in the UCR).[3] We created a separate category for pickpocketing and purse-snatching as opportunistic crimes that may take advantage of high concentrations of people. We excluded domestic offenses and crimes inside buildings, residences, hospitals, and schools.[4] We used block group crime counts to compute crime rates per 1,000 residents and commuting workers (Table A1 in the Technical Appendix).[5]

We used additional sources to compute measures of activity density, land use attributes, amenity richness, transit accessibility, street connectivity (i.e., walkability), and e-bike use around station areas. For these measures, we used data from the Chicago Metropolitan Agency for Planning, the U.S. Environmental Protection Agency's Smart Location Database, the 2019 Longitudinal Employer–Household Dynamics, Walk Score Inc., the American Community Survey 2019, and Chicago's Open Data Portal for e-bike trips, CBD boundaries, and station locations (Chicago Data Portal, 2020; Chicago Metropolitan Agency for Planning, 2015; U.S. Census Bureau, 2020; U.S. Census Bureau Center for Economic Studies, 2020; U.S. Environmental Protection Agency, 2020; Walk Score, 2014). Table A3 in the Technical Appendix provides further information about these data sources and variables.

Using these sources, we created a variety of measures. We calculated activity density as the sum of total population and employment on census blocks whose centroids fell within the transit station catchment area and divided by land area in square miles. We measured land use attributes in two ways. First, we calculated the portion of TOD-supportive land uses (offices, education, commercial, and public service uses; see Table A2 in the Technical Appendix). Second, we computed the land use entropy index.[6] This index measures balance between the four different land uses mentioned earlier. It ranges from 0, where all land is in a single use, to 1, where land is evenly divided among the four uses. Values were intermediate when station areas had two or more uses but one use predominated. Because activity density already accounts for residential density, we

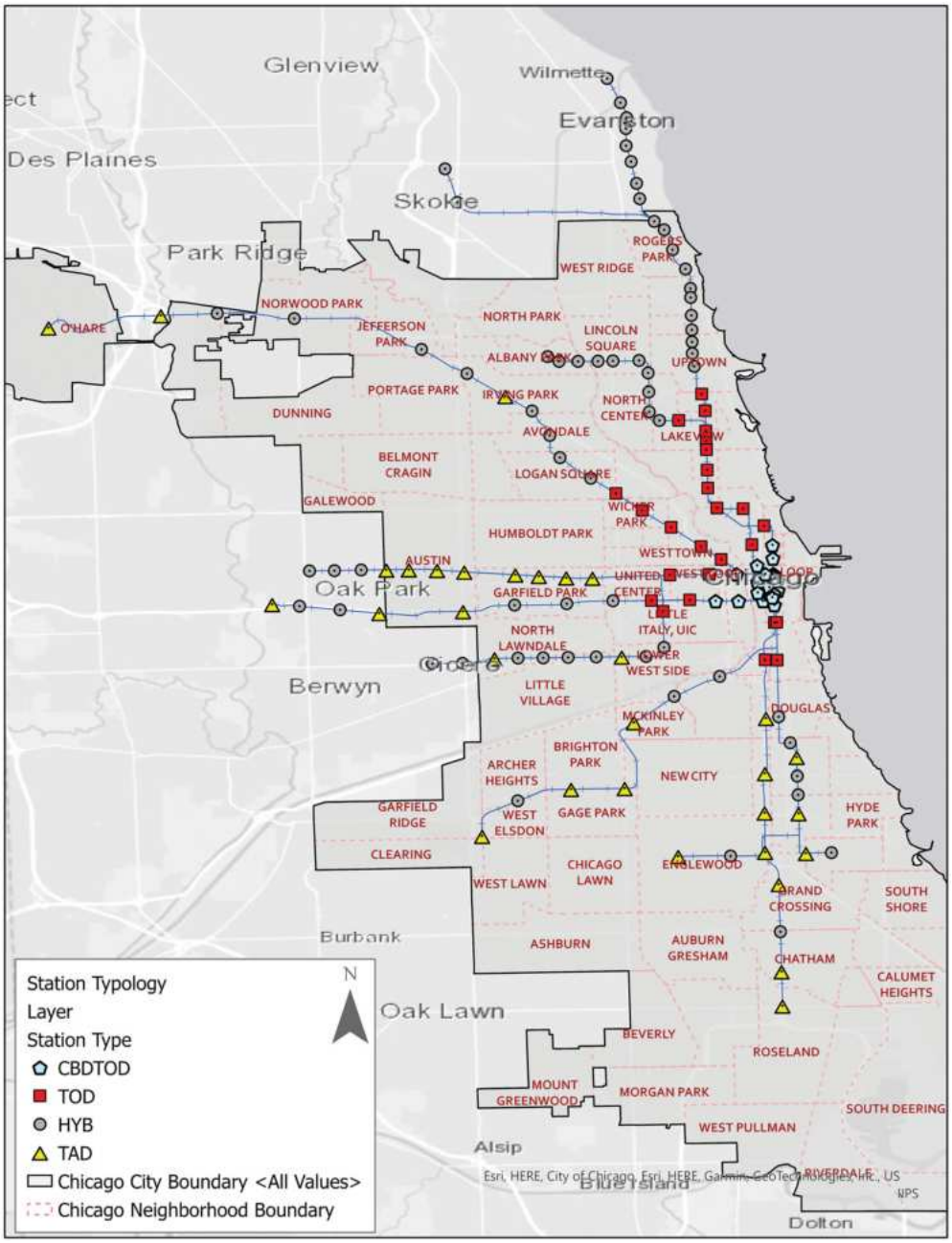


*Figure 1. Cluster analysis results: transit station typology.*

focused on the other land uses supportive of TOD success.

We used data from Walk Score Inc. to obtain station area's amenity richness and transit accessibility. The Walk Score uses walking routes to measure proximity to certain amenities (e.g., restaurants, coffee shops, retail, entertainment), which are weighted differently and discounted as the distance to them increases up to 1.5 miles. Beyond that distance, they are assumed to be inaccessible on foot. We obtained these data using the Walk Score API. We could only access the most recent Walk Score corresponding to year 2020. Because this score is measured using urban amenities and built environment data, which do not experience a significant change during a 3-year period, the 2020 score should accurately capture the 2019 amenities context. The Walk Score does not measure the presence and quality of sidewalks. It measures distance to destinations

by applying a distance decay function, so we included street connectivity as another measure of walkability. Street connectivity was measured through street intersection density weighted to eliminate auto-oriented intersections.

Using the U.S. Environmental Protection Agency's Smart Location Database, we calculated intersection density to account for pedestrian and nonmotorized pathways; however, we did not include the presence or quality of sidewalks. We also included Transit Score provided via Walk Score Inc. to account for the overall transit accessibility of a rail station. Transit Score also measures public transit quality. It uses data from public transit agencies through the General Transit Feed Specification and includes stops and routes for available modes of public transportation (e.g., buses, light/heavy rail). Transit Score assigns a value to all nearby routes for an address weighting heavy/light rail transit more than buses and other forms of transportation. It adds a penalty based on distance to the nearest stop.[7]

Last, we used data on all e-bike trips.[8] We aggregated these trips for a given station area and calculated the number of e-bike trips per working-age (16–64 years) person. Table A3 in the Technical Appendix provides descriptive statistics of these measures.

## Methods

### STATION AREA CLASSIFICATION: CLUSTER ANALYSIS

In 2019, there were 144 transit stations in Chicago, and not all of them were TODs. The built environment associated with transit stations falls within a transit-oriented to non-transit-oriented (i.e., transit-adjacent) spectrum, rather than a dichotomous scale. Furthermore, there is no agreement regarding the ideal built environment for TODs. Thus, identifying TOD stations and distinguishing them from other transit development types is a difficult but important research step. To this end, we used cluster analysis to identify a transit station typology. This method has been used widely to analyze TODs in the United States and abroad (Atkinson-Palombo & Kuby, 2011; Cervero & Danielle, 2014; Kamruzzaman et al., 2014; Lyu et al., 2016; Woo, 2021).

First, we identified transit catchment areas as a 1-mile network distance from a transit station. Although TOD ordinances in Chicago suggest 0.5 mile, we used a distance that individuals would walk to reach a station. According to Canepa (2007), supportive built environments can increase this distance to 1 mile, which has become the norm in the literature that quantifies TOD (Dong, 2017b; Huang et al., 2017). Using a 1-mile distance made our work more comparable to the literature. Then, in line with prior literature (Atkinson & Easthope, 2009; Scheer et al., 2017), we conducted a cluster analysis using a hierarchical clustering algorithm with average distance measures to classify area types based on five built environment factors that have been extensively suggested in the literature (Renne & Ewing, 2013; Scheer et al., 2017; Zhou et al., 2020): activity density, land use attributes, amenity richness, transit access quality, and street network design. We added e-bike trips to the cluster analysis to capture the micro-mobility context supporting first- and last-mile nondriving trips in a station area for a total of seven input variables for the cluster analysis.

Several studies have classified transit stations in three categories: TOD, transit-adjacent development (TAD), and hybrid (Renne & Ewing, 2013); however, this categorization method is based on arbitrary thresholds of the built environmental factors. In this study we used statistical methods to identify the number of clusters. We determined the optimal number of clusters using the NbClust package in R 3.4.2 software (Charrad et al., 2014). The cluster analysis allowed us to group station areas based on their built environmental characteristics, as well as attributes that can increase on-street activity (e.g., amenity richness or e-bike trips). All seven variables used in the cluster analysis were standardized to make the variance across them equal.[9] The initial clustering showed that CBD stations were outliers with extreme high values for each of the factors, so we excluded them from subsequent clustering and treated them as their own cluster. For the rest of the stations, we tried four clustering methods. Three of the methods suggested three clusters, and only one method yielded four clusters. We validated the three clusters via average silhouette index. With these three clusters and the CBD cluster, we identified four station types. Figure 1 shows the geographical distribution of the station area types. CBD–TOD are clustered around the downtown area of Chicago. TODs are closest to CBD–TODs stretching away from the CBD to the north and Oak Park Village (a historical neighborhood in the Chicago suburbs). TADs are dispersed with several in the West and South Sides of Chicago. Most stations in the South Side are hybrid and TAD types.

Table 1 shows the built environment summary statistics by station type. CBD–TOD stations ($n = 22$) had substantially higher activity density and had higher land use diversity (0.52 entropy) than the other station types. They also had more amenities and transit access as well as e-bike trips. CBD–TOD station areas also had higher street intersection density. The second station type is TOD stations ($n = 26$). These are stations that shared some CBD–TOD attributes (amenity richness and street intersection density) but were not located in the CBD and had much lower activity density compared with CBD–TODs as well as a lower transit score and fewer

daily e-bike trips per capita. The third category is hybrid stations ($n = 65$). These were in areas with built environment features between TOD and TAD stations. They had lower activity density (on average, 22.78 residents and jobs in 1,000 $mi^2$), lower entropy, and a lower percentage of TOD land use attributes (15.20% on average). Amenity richness was relatively high with a score of 84.78, and the transit score was 66.29, indicating "good transit" (i.e., many nearby public transportation options; Hirsch et al., 2013). There were very few e-bike trips per person, and street connectivity density was 191.92 intersections per square mile. TAD stations ($n = 31$) were those with the least activity density, entropy, and land uses typical of TODs. These areas had low scores on amenity richness and transit, and street connectivity was also lower.

## UNADJUSTED MEAN DIFFERENCES AND PROPENSITY SCORE MATCHING

We defined block groups in a station area as those within a 1-mile network distance around a Chicago Transit Authority station, allotting block group population centroids to their nearest station. Our final sample included 1,059 block groups across the four station area types. These block groups were located throughout Chicago and varied substantially in their sociodemographic characteristics and crime rates. Thus, we first examined sociodemographic and crime mean characteristics by station area type. We tested whether these means were significantly different using analysis of variance. We focused on characteristics identified as predictors of crime (Buonanno, 2003): population below poverty, percentage of Black residents, percentage of residents with less than a college degree, percentage unemployed, percentage of vacant units, and the age profile of residents.

Although this method allowed us to identify significant differences across the station area types, these unadjusted means were insufficient to extract meaningful conclusions about the station area built environment and crime. That is, any observed differences in crime rates could simply be reflecting differences in sociodemographic characteristics across station types. Therefore, we used PSM for the main analyses.

PSM allowed us to select comparison block groups that shared similar sociodemographic characteristics except for the built environment around the station area. For example, to estimate the relationship between a specific station type and crime, we matched block groups in this station type to those in other station areas that were otherwise similar across sociodemographic factors. In this way, PSM allowed us to obtain a subset of block groups that were observationally similar but that differed on station area features, thus reducing the threat of omitted variable

**Table 1. Mean built environment characteristics by station type.**

| Station area type | No. stations | | Activity density[a] in 1,000 (/$mi^2$). | | Entropy index[b] | | % of TOD land use[b] | | Amenity richness[c] | | Transit score[c] | | Daily e-bike trips per capita[d] | | Intersection density[e] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *N* | % | Mean | *SD* | Mean | *SD* | Mean | *SD* | Mean | *SD* | Mean | *SD* | Mean | *SD* | Mean | *SD* |
| CBD–TOD | 22 | 15 | 250.8 | 42.31 | 0.52 | 0.04 | 30.2 | 3.13 | 97.05 | 3.11 | 98.96 | 3.12 | 64.2 | 14.8 | 316.6 | 74.36 |
| TOD | 26 | 18 | 45.17 | 25.59 | 0.4 | 0.08 | 20.76 | 5.88 | 92.04 | 8.27 | 81.77 | 6.96 | 19.4 | 11.3 | 235.9 | 46.87 |
| Hybrid | 65 | 45 | 22.78 | 91.85 | 0.26 | 0.09 | 15.2 | 4.88 | 84.78 | 11.02 | 66.29 | 8.86 | 2.01 | 2.17 | 191.9 | 44.01 |
| TAD | 31 | 22 | 14.45 | 6.95 | 0.04 | 0.1 | 12.55 | 10.1 | 63.45 | 14.85 | 69.42 | 5.5 | 0.45 | 0.75 | 117.7 | 61.08 |

Notes: There are a total of 144 stations in our cluster analysis. a. U.S. Census Bureau, 2020; U.S. Census Bureau Center for for Economic Studies, 2020. b. Chicago Metropolitan Agency for Planning, 2015. c. Walk Score, 2022. d. U.S. Environmental Protection Agency, 2020. e. City of Chicago Open Data Portal, 2020.

bias due to observed confounders. Although there could still be other unobserved factors that explain station area development and crime, PSM allowed us to isolate more robust associations than we would by comparing block groups in specific station types with all other block groups in Chicago.

To implement the PSM analysis, we first estimated a logistic regression of the station area type on the sociodemographic covariates described above,[10] and we predicted a propensity score for each block group. Using this propensity score we matched treated block groups (located in one of the four station area types) with untreated block groups (located in other station area types). We matched using a caliper length ranging from 0.03 to 0.001 depending on the station area type. That is, for treated block groups we found matches whose propensity scores were within 0.03 to 0.001 of the propensity score of the treated block groups (Austin, 2011; Groth et al., 2017). Choice of caliper was made based on efficiency considerations due to small sample sizes and to maximize balance across covariates. See Tables A11 and A12 in the Technical Appendix for balance test results.

To obtain mean differences in crime rates, we estimated a set of linear regressions in which the key dependent variable was one of the five crime rates and the key independent variable was one of the four station area types. We also included covariates used in the matching as controls to improve precision and because in some cases there were differences between the treated and matched samples. Regressions were estimated on the matched samples and weighted by the frequency of the matched controls.[11]

There were a few limitations in our analyses. First, even using PSM, we were unable to isolate causal estimates due to unobserved differences across block groups. Second, we used only 1 year of data. The 2019 data were sufficient for our analysis according to our sensitivity analysis results (Table A15 in the Technical Appendix), which showed block group–level crime did not have a notable change from 2017 through 2019 because the 2019 rates were almost the same as the 2017 and the 2017–2019 3-year average rates. Among the five crime types in our analysis, only burglary had a Pearson correlation coefficient of slightly less than 0.9 (between 2019 and 3-year average crime rates), whereas for the rest, the coefficients approached 1. Hence, the 2019 data were a good representation of long-term crime rates in the city before the COVID-19 pandemic. One year of data, however, did not allow us to estimate changes over time and, in some cases, it may have resulted in small sample sizes that complicated detecting statistically significant effects.

## Results

### *Sociodemographic and Crime Differences by Station Type*

Crime rates also varied significantly across station types (Table 2, panel A). On average, block groups in CBD–TOD station areas appeared to be the safest for violent crime (2.11 per 1,000 people) and robberies (1.49 per 1,000 people). Burglaries and thefts were also lower in CBD–TODs, but purse-snatching and pickpocketing incidents were higher. In contrast, TOD station areas had higher rates of property crimes compared with the other three types, whereas hybrid station areas had lower rates of property crimes than both TADs and TODs. These unadjusted crime differences, however, did not account for sociodemographic differences across the station types, which were substantial, as described in Table 2, panel B.

Station area types significantly differed across key sociodemographic indicators. Specifically, block groups in CBD–TOD stations had lower percentages of residents who were Black (5.59%), whereas those in TAD station areas had the higher percentage of Black residents (62.56%). Similarly, the percentage of unemployed persons was lowest in CBD–TOD station areas and was sequentially higher in TOD, hybrid, and TAD station areas. We observed a similar pattern regarding the percentage of persons in poverty and the percentage of persons with a college degree or higher. Hybrid stations had a higher percentage of persons 30 to 44 years of age, whereas TADs had higher percentages of persons 44 to 64 years old (though this difference was not statistically significant across station types). CBD–TOD areas had more persons 65 years old or more, followed by TAD and hybrid stations. Given these differences, it was unclear whether disparities in crime rates across station areas were the result of varying built environment features or due to these observable sociodemographic factors. We turn to PSM results in Table 3 to obtain more robust crime estimates.

### *Station Area Types and Crime: Propensity Score Matching Results*

After accounting for sociodemographic differences through PSM, the patterns showcased earlier changed. CBD–TOD, hybrid, and TAD station types appeared to be the safest, whereas TODs were the least safe station areas (Table 3). To be specific, block groups located in CBD–TOD station areas had 1.069 fewer violent crimes per 1,000 people compared with similar block groups in other areas, whereas those in hybrid station areas had 0.686 fewer violent crimes. Point estimates were negative across all crimes in these two station areas, suggesting these were the safest block groups. That said, in the case of CBD–TOD, coefficients were not statistically

**Table 2. Mean sociodemographic and crime characteristics by station area type.**

| | CBD–TOD | TOD | Hybrid | TAD | *p* value |
|---|---|---|---|---|---|
| | (*SD*) | (*SD*) | (*SD*) | (*SD*) | |
| A. Crime rates | | | | | |
| Violent | 2.11 | 2.67 | 4.32 | 8.68 | .000 |
| | (1.76) | (3.28) | (6.48) | (9.64) | |
| Robbery | 1.49 | 1.86 | 2.73 | 5.31 | .000 |
| | (1.55) | (2.66) | (4.79) | (6.12) | |
| Burglary | 0.26 | 0.59 | 0.57 | 1.03 | .000 |
| | (0.32) | (0.90) | (1.11) | (1.95) | |
| Theft | 17.99 | 19.20 | 12.75 | 15.00 | .000 |
| | (17.62) | (24.76) | (16.15) | (15.06) | |
| Purse-snatching/pickpocketing | 1.51 | 1.14 | 0.49 | 0.78 | .000 |
| | (2.07) | (3.30) | (1.14) | (1.86) | |
| B. Sociodemographic characteristics | | | | | |
| % Black | 5.59 | 10.01 | 27.54 | 62.56 | .000 |
| | (6.70) | (18.21) | (36.28) | (41.69) | |
| % Unemployed | 3.22 | 2.69 | 5.43 | 9.28 | .000 |
| | (3.63) | (3.35) | (5.04) | (6.88) | |
| % College degree | 84.99 | 78.06 | 45.21 | 20.65 | .000 |
| | (10.21) | (17.88) | (22.62) | (13.10) | |
| % Poverty | 11.95 | 11.96 | 21.72 | 30.41 | .000 |
| | (9.61) | (10.59) | (16.53) | (17.90) | |
| % Age 30–44 years | 27.19 | 32.10 | 0.37 | 25.70 | .014 |
| | (12.21) | (12.34) | (11.02) | (10.07) | |
| % Age 45–64 years | 24.46 | 20.54 | 28.23 | 30.15 | .583 |
| | (10.43) | (9.46) | (9.54) | (9.04) | |
| % Age 65 years or more | 19.06 | 12.17 | 14.82 | 18.15 | .000 |
| | (15.71) | (12.46) | (10.05) | (9.92) | |
| % Vacant | 16.54 | 9.36 | 13.35 | 17.39 | .000 |
| | (8.11) | (7.76) | (10.49) | (11.00) | |
| No. block groups | 49 | 245 | 538 | 227 | |

Notes: Standard deviations in parentheses. *p* Value from analyses of variance. There are 1,059 block groups in the sample. These are block groups within 1 mile of a transit station. Crime rates per 1,000 people calculated over residents and commuters. Violent crimes included homicide, aggravated assault, robbery, and rape.
Source: American Community Survey and historical crime data from the Chicago Open Data Portal (Chicago Open Data Portal, 2020; U.S. Census Bureau, 2020).

significant but, given the small sample, we may have been underpowered to detect these differences. In contrast, block groups in TOD station areas were the least safe, with more property crimes than the other areas. Specifically, TOD areas had more burglaries (0.207 per 1,000 people) and more incidents of theft (4.296 per 1,000 people). Although coefficients for purse-snatching and pickpocketing as well as robbery were positive, they were not statistically significant. Finally, crime rates in TAD areas did not differ from non-TAD matched block groups, except they experienced 4.950 fewer thefts per 1,000 people.

### *Station Area Types and Crime: Pairwise Comparisons*

One limitation of these analyses was that the comparison group included block groups from the different station areas, so it was unclear how crime rates in specific types compared with others. Table 4 shows results of pairwise comparisons of each station area type.[12] These results show that TOD station areas had more violent and property crimes across all categories when compared to CBD–TODs (panel A) and to hybrid station types (panel B), but they may be safer than TAD station areas, especially regarding thefts, with 12 fewer thefts

**Table 3. Mean differences in crime rates among station area types and matched controls in Chicago, 2019.**

| | Crime | | | | |
|---|---|---|---|---|---|
| | Violent (1) | Robbery (2) | Burglary (3) | Theft (4) | Purse-snatching/ pickpocketing (5) |
| CBD–TOD | −1.069* | −0.630 | −0.067 | −5.637 | −0.686 |
| (caliper 0.03) | (0.521) | (0.406) | (0.096) | (3.917) | (0.713) |
| Observations | 94 | 94 | 94 | 94 | 94 |
| TOD | −0.056 | 0.096 | 0.207** | 4.296* | 0.170 |
| (caliper 0.01) | (0.306) | (0.239) | (0.078) | (2.057) | (0.211) |
| Observations | 416 | 416 | 416 | 416 | 416 |
| Hybrid | −0.686* | −0.376 | −0.181* | −2.856* | −0.317** |
| (caliper 0.001) | (0.389) | (0.270) | (0.091) | (1.139) | (0.112) |
| Observations | 810 | 810 | 810 | 810 | 810 |
| TAD | −0.278 | −0.773 | 0.131 | −4.950** | −0.018 |
| (caliper 0.03) | (0.740) | (0.532) | (0.154) | (1.810) | (0.142) |
| Observations | 434 | 434 | 434 | 434 | 434 |

Notes: Standard errors in parentheses. Estimates from regressions weighted by the matched controls frequency. All models include controls: percentage Black, percentage unemployed, percentage with a college degree or higher, percentage poverty, percentage aged 30–44, percentage aged 45–64, percentage aged 65 or older, percentage vacant. DV: dependent variable. Crime rates per 1,000 people (residents and commuters). *$p < .05$; **$p < .01$.

per 1,000 people (panel C). Hybrid station areas were only safer when compared with TODs, but they experienced more thefts than TADS (20.340 more thefts per 1,000 people) and more violent crimes than CBD–TODs (0.408 per 1,000 people). In sum, these analyses indicate that the combination of built environment features in CBD–TOD was associated with safer station areas, whereas that in TODs correlated with higher crime. Specifically, higher levels of amenity density, connectivity, and amenity richness correlated with less crime, whereas lower levels of density and connectivity combined with high amenity richness as found in TODs correlated with higher rates of violent and property crimes.

## Conclusion and Implications for Planning Practice

We investigated the relationship between the built environment attributes of station areas and crime. We used cluster analysis to identify four station area types (CBD–TOD, TOD, hybrid, and TAD) and propensity score matching to compare block groups with different types that were similar on key sociodemographic characteristics. In line with prior literature, the built environment around stations is an important correlate of violent and property crimes. Our results show that very high levels of activity density, land use diversity, amenity richness, and accessibility correlated with safer station areas as seen in CBD–TODs. However, a decline in activity density and land use diversity in the presence of high amenity richness, walkability, and accessibility correlated with more crime as seen in TODs. At low levels across all these measures, we also observed worse safety.

In sum, we found that TOD station areas were the least safe when compared with CBD–TODs and hybrid stations, suggesting that lower activity density and land use diversity but high amenity richness and connectivity created situations for criminals to find potential victims. This is because TOD station areas may create environments in which criminals can encounter many potential victims but fewer guardians. Using the terminology in Block and Block (2000), some block groups in TOD station areas may be critical intensity areas conducive to crime. Further, the presence of potential criminogenic facilities in these areas based on the high amenity richness may also favor criminal activity. Coupled with high street connectivity and high transit accessibility, TODs may have higher crime because they may be environments that favor opportunity and access and provide the means for perpetrators to escape.

Overall, results seemed to support the eyes on the street perspective that indicates places with higher density, land use diversity, and amenity richness have fewer crimes. These findings also align with existing research. In light of our findings, planners could consider favoring increasing density and land use diversity in TOD areas with high amenity richness and connectivity to potentially deter some criminal activity. That said, our study did not aim to identify the presence of specific criminogenic facilities in these areas such as bars or restaurants, which the literature has shown play an important role in attracting violent crime. Future research should

**Table 4. Mean differences in crime rates among station area types paired with matched controls in Chicago, 2019.**

| | Crime | | | | |
|---|---|---|---|---|---|
| | Violent (1) | Robbery (2) | Burglary (3) | Theft (4) | Purse-snatching/ pickpocketing (5) |
| A. | | | | | |
| TOD–CBD–TOD | 0.841** | 0.635** | 0.358** | 9.489** | 0.627* |
| (caliper 0.03) | (0.188) | (0.146) | (0.067) | (1.752) | (0.271) |
| Observations | 428 | 428 | 428 | 428 | 428 |
| B. | | | | | |
| TOD–Hybrid | 1.343* | 0.997* | 0.328* | 14.580** | 1.228* |
| (caliper 0.001) | (0.533) | (0.403) | (0.132) | (3.861) | (0.545) |
| Observations | 154 | 154 | 154 | 154 | 154 |
| C. | | | | | |
| TOD–TAD | −0.329 | −0.707 | −0.260 | −12.624** | 0.035 |
| (caliper 0.03) | (0.790) | (0.656) | (0.194) | (4.525) | (0.222) |
| Observations | 116 | 116 | 116 | 116 | 116 |
| D. | | | | | |
| Hybrid–TAD | −0.270 | −0.406 | 0.015 | 2.340** | 0.049 |
| (caliper 0.03) | (0.374) | (0.276) | (0.079) | (0.894) | (0.081) |
| Observations | 980 | 980 | 980 | 980 | 980 |
| E. | | | | | |
| Hybrid–CBD–TOD | 0.408* | 0.169 | 0.112 | 1.728 | −0.103 |
| (caliper 0.03) | (0.204) | (0.144) | (0.073) | (1.604) | (0.067) |
| Observations | 352 | 352 | 352 | 352 | 352 |

Notes: Standard errors in parentheses. Estimates from regressions weighted by the matched controls frequency. All models include controls: percentage Black, percentage unemployed, percentage with a college degree or higher, percentage poverty, percentage aged 30–44, percentage aged 45–64, percentage aged 65 or more, percentage vacant. *$p < .05$; **$p < .01$.

examine the role that these facilities play in moderating the relationship estimated in this study.

Another key takeaway for planning and practice lies in the built environment differences between CBD–TODs and TODs. Although both station area types seem similar in terms of TOD attributes, CBD–TODs have substantially higher values of activity density and e-bike use, which are clearer indicators of foot traffic in public spaces. Thus, when it comes to TOD planning, these two attributes directly support transit ridership (key success of TODs), but to the extent that they also support safer environments, they may further incentivize ridership and an active lifestyle. Therefore, TOD planning efforts should not only continue to encourage dense and mixed use developments in new station areas, but further policy efforts may also focus on lowering vacancies in the existing TOD and hybrid station areas with vacant buildings. Further, increasing activity density should involve a housing supply that supports both high- and low-wage jobs in TODs. Although previous studies showed that TODs have been the target of high-tech jobs and workers in the United States (Zandiatashbar & Hamidi, 2018, 2021; Zandiatashbar et al., 2019), TOD amenity richness attracts low-wage workers to this area; if they could live and work in TODs, it would further boost activity density and foot traffic, potentially contributing to safer environments through increasing social control.

Given the connection between safety and health shown in the literature, higher crime in areas with medium activity density and land use diversity may discourage the potential health benefits of high amenity richness and connectivity. Although our study did not examine physical activity or other health outcomes, planners interested in how design features may promote health should consider the opposing forces that may be at play in TOD areas. Features that promote physical activity (amenities and walkability) may also contribute to crime, deterring people from an active lifestyle in environments with medium density and land use diversity. Future work should analyze health indicators to draw this connection explicitly.

Further, because the hybrid station type was the largest cluster in our analyses, it provides the

opportunity for planners to tap into its potential. To do so, future research should specifically focus on hybrid station types to try to parse in more detail their variation across built environment features and how it correlates with crime. For instance, density comes in many shapes and forms, resulting in different urban experiences. A promising area for future research could try to quantify this variation and create more nuanced density measures.

A few limitations merit further exploration in future studies. First, although we were able to isolate robust associations between station area types and crime, our study was not causal. Future work should use stronger empirical approaches to derive causal estimates. Second, our analyses relied on 1 year of crime data, which is insufficient to examine changes over time. This is important because Chicago and many other cities have passed ordinances that favor specific development around transit stations. Future work should take a longitudinal approach to estimate how changes induced by these ordinances correlate with crime. Finally, our measures of the built environment prioritized use, and follow-up work should explore measures that also capture the physical elements of the built environment.

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## SUPPLEMENTAL MATERIAL

*Supplemental data for this article can be found on the publisher's website.*

## NOTES

**1.** Given the growth of micro-mobility (Elmashhara et al., 2022), we thought it was important to include it in our typology.

**2.** In 2019 geographic coordinates were missing for less than 1% (0.47%) of crimes.

**3.** This category includes all forms of theft except financial ID theft.

**4.** We used the primary type field to identify the type of crime. To identify domestic offenses, we used the domestic offense flag in data. To exclude crimes in residences, hospitals, and schools we used the location of the crime. Crimes inside buildings included elevators and hallways.

**5.** We calculated that there were 11,891 violent crimes, 7,278 robberies, 47,428 thefts, 1,887 burglaries, and 2,721 incidents of purse-snatching or pickpocketing in 2019.

**6.** The entropy calculation is: Entropy $= -$ [Office share * ln(Office share) + Education share * ln(Education share) + Commercial share * ln(Commercial share) + Public share * ln(Public share)]/ ln(3), where ln is the natural logarithm of the value in parentheses and the shares are measured in terms of total parcel land areas.

**7.** For more details on the Transit Score calculation, see Walk Score (2022).

**8.** For more information on Chicago's e-bike (Divvy) program, see Divvy (2022).

**9.** Table A6 in the Technical Appendix shows descriptive statistics for the unstandardized values.

**10.** We found no evidence of multicollinearity. See Table A8 in the Technical Appendix. The Technical Appendix provides step-by-step information on the PSM.

**11.** We also estimated models without controls and obtained similar results (Tables A13 and A14 in the Technical Appendix).

**12.** The TAD–CBD–TOD comparison was excluded due to the inability to find good matches.

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