Traffic Signal Equity: Crossing the street to active transportation

Cathy Tuttle

Seattle Neighborhood Greenways

Peter House, Genya Shimkin, Amber Bronnum, Clarissa Lord Brundage, Elizabeth Burpee, Nick Canavas, Jennifer Morton, Barbara Obena, Sierra Rotakhina

University of Washington School of Public Health

Abstract

One of the most significant barriers to active transportation is simply crossing the street, particularly crossing arterials (Koonce 2013). This study tests whether traffic signals in low-income communities favor motorized vehicles far more than they do in higher income communities. Signal timing and the difficulty of crossing the street has negative cascading effects on community well-being and public health (Rutt, Dannenberg, Kochtitzky 2008) – perceived safety, pedestrian injury and collisions, fewer people walking and biking, health effects of less active transportation heart disease and obesity, economic vibrancy of small business nodes. Three sets of street crossings (6 total) were studied by graduate students at the UW School of Public Health and community volunteers. Two sets of crossings are in the Rainier Valley, Seattle's most ethnically diverse community, and one control matched set is in more homogeneous and higher income Ballard area of north Seattle. Pedestrian volume, delay data, jaywalking at intersections were recorded. Key informant and user experience accounts were collected. This study was prompted by people who live and work in the Rainier Valley who repeatedly emphasized during public meetings they did not have enough time to safely cross their streets. Their concerns were validated by one of the significant findings of this study. Cross Time/Distance (feet/second) has a statistically significant difference by income level. In Ballard with transit, freight, and >23,800 daily vehicles, pedestrians can cross the street at 2.0 to 2.8 feet/second. In Rainier Valley, with comparably active vehicle volumes, pedestrians had to hurry across their streets at 3.1 to 3.9 feet/second.

Keywords: public health, built environment, "crossing desert"

Imagine standing on a street corner, waiting for the light to turn green. You are holding two heavy bags of groceries. You lift up one tired hand to press the "Walk" button again. Daylight is fading. It is the end of a long week.

Figure 1. Waiting to Cross on Rainier

You look up at the slight hill heading towards the six-block walk to the light rail station and feel even more tired. You watch two lanes in each direction of trucks rumble by, the wheezing buses, cars waiting in the center turning lane, the impatient motorists zipping through at the last possible second as the signal finally changes to your green "Walk". You look over your shoulder to check and make sure no distracted driver is charging through the red light. You step out into the street and cross one lane, two lanes, walking briskly across the third lane when the "Walk" begins to flash "Don't Walk", "Don't Walk", "Don't Walk". You hurry up the slight hill towards the final lane and an impatient driver

Figure 2. Waiting to Cross on Rainier

barely misses you as he takes a right on red behind you. You see another car edging into the intersection and you know it isn't safe to look too closely at a person in their car, so you hurry forward. You still haven't reached the other curb when the light changes to red and cars seem to

Figure 3: Crossing Deserts

Low income neighborhoods can have "crossing deserts", in much the same way that low income neighborhoods often have "food deserts" Larsen & Gilliland J. (2008)**.**

The simple act of getting across the street by walking and biking, on your way to work, to the store, to pick up your child at school, or to simply cross the street to greet your neighbor can be hampered by the following:

1. Fast-moving arterials with distantly placed signals;
2. Geography at intersections across arterials – even intersections with signals – that lack curb bulbs, advance stop lines, "no right on red" signs or other engineering features that allow for safer crossing for people;
3. Finally, the signals themselves can have timing and design qualities that favor motorized vehicles over people.

It is this final category of signal timing and design equity that this paper is about, but all aspects of "crossing deserts" are a ripe area for future research.

leap towards you from all directions as you sprint the final few feet to safety on the opposite side of the streets. Imagine doing this walk when you go with your kindergartener to her first day of school. Imagine doing this walk when you are 20 years older.

Now imagine a different intersection. You are standing on the street corner laden down with groceries for dinner, waiting for the light to finally change to your green "Walk". You are eager to get to the other side of the street and go home. When the signal changes, you look both ways for distracted drivers beating the red. You think people drive crazy these days, and think about the Washington State law that said people couldn't talk on the phone or text and drive. Whatever happened to that?

If you were a transportation engineer or planner, you'd know you were crossing a freight and transit corridor carrying over 22,000 vehicles a day. You step into the street. Because it was a long day, you notice you actually have to walk slightly uphill as you cross the street. You catch

the eye of a driver nosing into the intersection and about to make a right on red and he stops. You get safely to the other side of the street and walk home.

This paper does not address "crossing deserts" – the long expanses of heavy and fast-moving roadway people must traverse between traffic signals and often found in with high economic and cultural diversity. Traffic signals have their own unique equity issues. The traffic signal functions as a narrow bridge across a raging torrent of moving, jostling, distracted drivers intent first on interactions with other vehicles and with whatever dramas are going on within their own cars. We have an obligation as planners and traffic engineers to make these narrow bridges as sturdy and reliable as possible. We can buttress the foundations of arterial crossings with curb bulbs and islands to shorten the passage of how far people need to walk or bike in the roiling water of traffic. We can stop traffic more effectively with red light cameras, distracted driver enforcement, and no right on red ordinances. Ultimately we as a society need to decide to build the best bridges possible across traffic in a way that keeps everyone focused, predictable and alert. Well-placed, designed and timed signals support local businesses, children walking to school, neighbors getting to know each other in our communities.

Environments that promote active transportation are essential to the promotion of safe and healthy communities. Being able to safely cross a street on foot or by bike is critically important to a safe environment. In February 2013, Seattle Neighborhood Greenways asked eight University of Washington Master in Public Health students to conduct a study on the barriers people face crossing a busy arterial in two neighborhoods where residents reported difficulty crossing the street: Columbia City and Rainier Beach (Bronnum, et al. 2013). While observations focused only on pedestrians, this study has relevance to people riding bicycles and other forms of active transportation.

Results indicate there is a significant difference between crossing time in the higher- and lower-income neighborhoods studied. The higher-income neighborhood had significantly longer crossing times, but there was no significant difference in pedestrian delay. The findings partially support the hypothesis that signal timing in the lower- income neighborhoods studied favor vehicles. However, a direct association between neighborhood median household income and signal timing cannot be made and results included in this report are not generalizable without further observations at more sites.

The study teams also conducted a sample of resident intercept surveys with pedestrians and key informant interviews to identify barriers associated with crossing the street. Respondents supported the claim that signal timing is a barrier to crossing the street in the two lower- income focus neighborhoods, while identifying several additional barriers related to traffic considerations, personal safety, and the built environment. Respondents in the higher income area did not perceive signal timing as a barrier to crossing the street.

From a built environment and public health perspective, signal timing, signal delay, and intersection conditions are worthy of broader research. In the immediate term, government and community partners action on signals is essential to facilitate positive and sustainable change in the Columbia City and Rainier Beach neighborhoods.

Health and Transportation

In 2012, Surgeon General Regina Benjamin announced the nation's first-ever National Prevention Council Action Plan, which strives to "move our health system from one based on sickness and disease to one based in wellness and prevention." The plan specifically addresses

transportation and encourages the development of walkable communities, bike lanes, and other healthy transit options.

Public health emphasizes the value of incorporating transit in "healthy communities." Healthy communities provide residents with access to food and services; a sense of safety and community; physical activity; and clean air. Unfortunately, the transportation infrastructure in the United States still favors automobiles which creates fewer options for people to move around and interact with services and people in their environment. The National Prevention Council (2012) indicates that a lack of alternative transportation options may have negative consequences related to physical activity, injury and prevention, air quality, and mental health status.

The ability to safely cross the street requires sufficient time to get from one side of the street to the other. Traffic signal delay can make pedestrians wait too long for a "Walk" signal. People may become discouraged from using the crosswalk or may cross against the light. Additionally, Wang (2011) has found pedestrians may ignore the "Walk" and "Flashing Don't Walk" signals if they do not provide sufficient crossing time. Long wait times and crossing distances, pedestrian direction of travel, number of pedestrians crossing, and the distance between crosswalks contribute to pedestrian experience and jaywalking (Hubbard, Bullock, & Day 2008).

According to aggregate King County data, there were 101 pedestrian fatalities and 625 serious pedestrian injuries from 2006 to 2010 (Public Health Seattle & King County 2013). The National Center for Environmental Health (2012) shows that almost three-fourths (73%) of pedestrian fatalities occurred in an urban setting and nearly 80% of pedestrian fatalities occurred at non-intersections—commonly the result of a vehicle collision with a jaywalker .

A recent study by Moudon, Lin, Jiao, Hurvitz & Reeves (2011) examining injury severity among pedestrian-motor vehicle collisions in King County found that the neighborhood environment and design was a significant factor in pedestrian safety. Higher residential densities and lower median home values were associated with a higher risk of severe injury or death.

When people feel unsafe crossing their neighborhood streets they are less likely to walk or bike. Improved access to neighborhood destinations has been shown to increase walking as a mode of transportation (Sugiyama et al. 2012). A safe street is a walkable street. A walkable street is a public health benefit. Sallis et al. (2009) reports adults who live in high-walkability neighborhoods are less likely to be overweight or obese than those living in low-walkability neighborhoods.

Table 1: Neighborhoods studied

Type	Neighborhood	Intersection A	Intersection B
Focus	Columbia City	Alaska & Rainier	Edmunds & Rainier
Focus	Rainier Beach	Henderson & Rainier	51st & Rainier
Comparison	Ballard	24th & Market	22nd & Market

Rainier Avenue South (referred to as "Rainier") is a major freight and transit corridor in south Seattle, Washington that bisects the Columbia City and Rainier Beach neighborhoods. Rainier divides dense residential areas from major public transit access points, forcing pedestrians to frequently cross at busy intersections. Rainer also functions as a major thoroughfare connecting residents of South King County to downtown Seattle and major freeways.

Columbia City mixes small business retail, a library, community center, and major athletic field in its busy core. Rainier Beach has a mix of several public schools, a community center, library, and retail. Due to this unique combination of vibrant neighborhood activity and the fast-paced nature of Rainier as a commuter route, pedestrians in these two neighborhoods have repeatedly

expressed difficulty crossing the street to Seattle Neighborhood Greenways planners. Ballard is a thriving commercial business district with a mix of people walking and biking, cars, trucks, and buses. Signals are place at every block along the Ballard commercial corridor being studied, along with mid-block crossing signals.

In February 2013, Seattle Neighborhood Greenways asked eight University of Washington Master in Public Health students to conduct a study on the barriers residents face crossing a busy arterial road in Columbia City and Rainier Beach. The overarching research question that informed our study design was, "What are the barriers associated with pedestrians crossing the street in Columbia City and Rainier Beach?" Students conducted two studies to further understand pedestrian experiences:

1. Signal timing: The signal timing study was designed to test the hypothesis that traffic signals favor vehicles in the lower-income focus neighborhoods studied compared to the higher-income comparison neighborhood.
2. Community perception: The community perception study was designed to collect and analyze local informants' perceptions of the barriers to crossing Rainier Avenue South in the Rainier Beach and Columbia City neighborhoods.
3. Control study: A third study in March 2013 by local community volunteers using intercept studies was done in the higher income Ballard neighborhood.

The signal timing study was designed to test the hypothesis that traffic signals favor vehicles in lower-income neighborhoods compared to higher-income neighborhoods. To determine whether there is a statistically significant difference in traffic signal timing by neighborhood, the study team examined signal delay, the length of time pedestrians had to wait at select

intersections before receiving the "Walk" signal and how much time they had to cross the street.

Seattle Department of Transportation (SDOT) Traffic Signals confirmed that NW Market Street (referred to as "Market") in Ballard as an appropriate comparison from a traffic signal and traffic volume perspective to the focus neighborhoods along Rainier. The six specific intersections were selected based on location in the neighborhood, proximity to businesses, vehicle volume, and their multiple functions serving freight, transit, vehicle and active transportation users.

Table 2. Key demographic data for Columbia City, Rainier Beach, and Ballard (Seattle Department of Transportation 2011) (US Census Bureau 2010)

Characteristic	Columbia City	Rainier Beach	Ballard
Race			
White	33%	26%	85%
Non-white	67%	74%	15%
Average daily vehicles	26,200	22,000	23,800
Median household income	$47,500±$12,326	$45,956±$8,214	$72,443±$5,260

Of the three study sites, according to Seattle Department of Transportation (2013) pedestrian injuries and fatalities in study intersections are highest in Columbia City (n=36), followed by Rainier Beach (n=22), and finally Ballard (n=5).

Signal timing, pedestrian volume, and jaywalking were observed at all study intersections. Note that only in Ballard, signals are automatically activated for people walking and biking, arguably an inequitable distribution of resources (Koonce 2013).

Table 3. Study intersection descriptions

	Ballard		Columbia City		Rainier Beach		Total
	24th & Market	22nd & Market	Alaska& Rainier	Edmunds& Rainier	Henderson &Rainier	51st & Rainier	
Crosswalk Distance (ft)	47.9	52.3	78.6	57.6	57.1	66.0	N/A
Mean							

crosswalk distance/total cross time (ft./sec)	2.8	2.0	3.9	3.1	3.4	3.6	3.1
Frequency of observations	61	108	46	92	72	26	402
Mean pedestrian volume	2.6±2.0	5.7±4.1	1.8±1.5	2.6±1.8	2.8±2.0	1.0±0.9	3.3±3.0
Mean jaywalkers	2.4	6.3	2.2	2.4	8.0	6.1	4.6

Traffic signal observations were recorded for a total of 21.5 hours over the course of three days at different time periods (morning, afternoon, and evening). All of the study intersections are statistically different. The most notable comparisons between intersections exist in the mean crosswalk distance to total time to cross ratio; mean jaywalkers; and mean pedestrian volume (Table 3).

Data were cleaned and exported to SPSS (version 18) for coding and analysis. Descriptive statistics and frequencies were conducted on key variables. We then ran analysis of variance statistics to determine whether there were statistically significant differences by intersection and by neighborhood. A linear regression was performed to determine whether the study intersections were statistically significantly different.

Figure 4: Photographs of Study Areas

NW Market St.
& 22nd Ave NW

Rainier Ave S
& S Alaska St.

Rainier Ave S
& S Henderson St.

Results

This study was prompted by people who live and work in the Rainier Valley who repeatedly emphasized during public meeting they did not have enough time to safely cross their streets. Their concerns were validated by one of the significant findings of this public health study. Cross Time/Distance (feet/second) has a statistically significant difference in Ballard, Columbia City, and Rainier Beach. In Ballard with transit, freight, and >23,800 daily vehicles, pedestrians had to cross the street at 2.0 to 2.8 feet/second. In Rainier Valley, with comparably active vehicle volumes, pedestrians had to hurry across their streets at 3.1 to 3.9 feet/second.

Rainier Beach Observations

- A number of cars sped down 51st and made a right on red onto Rainier without stopping.
- Car ran a red through crosswalk.
- On long waits, pedestrians hit the button repeatedly and seemed visibly impatient.

Ballard has the smallest mean crosswalk distance to total time to cross (Walk + Flashing Don't Walk time) ratio, followed by Columbia City, and then Rainier Beach with the largest value. This finding suggests that the pace at which a pedestrian must walk, on average, to successfully cross the crosswalks observed in Ballard is slower than for pedestrians crossing in the two focus neighborhoods. Additionally, the total crosswalk length or width of the arterial was longest at the four study intersections crossing Rainier.

Columbia City Observations

- Blind pedestrians were observed several times walking against the signal. When observers questioned why, the blind pedestrians said they were walking with the audible signal meant for the opposite side of the street but focused on their side.
- A mother with a toddler and a baby in a stroller was cut off by cars driving in front of her as she was trying to cross the crosswalk with the signal. This caused her not to cross during the first walk signal and to instead wait for the next signal .

Rainier Beach had the highest amount of jaywalking during the data collection period. Ballard had higher pedestrian volume than the two focus neighborhoods in Rainier Valley.

While the mean pedestrian delay time varies by intersection and neighborhood, this variation was not statistically significant (see Figures 3 and 4). Nearly 75% of all pedestrian delays across the study sites were more than 30 seconds. Ballard had the highest amount of total crossing time. Walk time observation data was cross-checked with SDOT signal timing cards. The Walk times provided by SDOT for the study intersections were similar to the Walk times observed during the study period.

In 2010, the Manual on Uniform Traffic Control Devices (MUTCD) revised federal standards on the crossing time calculation to 3.5 ft/sec. SDOT began enforcing this recommendation by adjusting signal timing at intersections on a case-by-case basis (Kemper personal communication, February 13, 2013). Our study findings suggest that signal timing was addressed first in higher income Ballard, with an advantageous 2.8 and 2.0 ft/sec for people walking and biking. Alaska & Rainier and 51st & Rainier have not been adjusted since the MUTCD 2010 revision. Signal timing at the Henderson and Rainier intersection appears to meet the new standard, but just barely.

This study also found significant signal delay in the lower income communities (Bronnum 2013). Pedestrian delay may also encourage jaywalking and according to Heinonen & Eck (2007) people who fail to properly utilize designated crossings are at higher risk for injury and death. These results are not generalizable to other neighborhoods or other intersections as they were not randomly selected and could vary greatly from other neighborhoods in Seattle and other cities. The study team created a mixed-method, in-person interview survey tool to understand pedestrians' and key informants' perceptions of crossing Rainier. The tool was designed to determine whether signal timing is a community concern. Interview surveys were multi-phase: Phase 1 had four quantitative questions and allowed respondents to elaborate

with qualitative responses; and Phase 2 had two follow-up qualitative questions. The survey topics included:

- Participant perceptions.
- Perceived barriers to crossing Rainier.

The study team approached pedestrians (n=160) on or near Rainier in the two study neighborhoods, and a separate team spoke with Ballard pedestrians (n=42). Twelve key informant (KI) interviews were conducted (Bronnum 2013).

Respondents in Columbia City and Rainier Beach reported statistically significant differences both in their primary mode of transportation and in the factors that make them feel unsafe when they cross Rainier. Respondents from Columbia City listed walking (57%) as their primary mode of transportation and 27% noted transit as their primary mode. In Rainier Beach, however, the majority of respondents (51%) listed transit as their primary mode of transportation and 31% noted walking as their primary mode. In Ballard, the majority of respondents (69%) listed driving as their primary transportation mode.

Feelings of safety

- "You know what I hate? When you're crossing in front of a car, a lot of times they'll speed up like they're trying to kill you or something." – Rainier Beach resident"
- Speeding is equally hurtful in affecting the walkability of crossing Rainier" - Columbia City business owner.

On a five-point scale in which 1 represented "very unsafe" and 5 represented "safe," Columbia City respondents reported feeling significantly safer (mean=3.7) crossing the street than respondents in Rainier Beach (mean=3.2) when crossing Rainier. Ballard residents edged out both with (mean=4.2) pedestrians feeling safe crossing the street.

When respondents elaborated on what contributed to their level of safety, many said it depended on location. “Location” was defined to include respondents feeling more or less safe on or in certain corners, crosswalks, and neighborhoods. Eleven respondents reported that location affects their level of safety. Four respondents mentioned that time of day influenced their safety, particularly in Rainier Beach, where pedestrians mentioned increased crime at night. Five respondents mentioned that perceived safety was dependent on their familiarity with the area.

As predicted, signal timing was a concern for a quarter of respondents in both neighborhoods (25% in Columbia City; 28% in Rainier Beach). Interestingly in Ballard, virtually none of the respondents said signal timing was an issue (4%) but several mentioned nearby signals where they felt unsafe.

Similar numbers of respondents listed “other” reasons for feeling unsafe while crossing Rainier on foot (21.4% in Columbia City; 20% in Rainier Beach). Among the 83 pedestrians and 12 KIs who provided qualitative answers, “other” factors contributing to feeling unsafe included drivers not respecting traffic lights; distracted and malicious drivers, and turning cars. The most common response from pedestrians and key informants regarding their experiences crossing the street in the two focus neighborhoods involved near-miss collisions with cars (n=12); admission of or witnessing jaywalking (n=11); and actual collisions with cars (n=5). Many of the near-miss collisions involved pedestrians running out of time when crossing, turning cars failing to see or yield to pedestrians, or cars running through signals.

When asked whether they had enough time to cross at the signal, the majority of survey respondents in both focus neighborhoods (64% in Columbia City; 53% in Rainier Beach)

reported they had enough time, but expressed concerns for other pedestrians in the community. A number of respondents (n=13) were concerned that older pedestrians, children, or those with limited mobility might not have enough time to cross the street.

Discussion

The hypothesis that signal timing is a community concern was partially supported by the results. Respondents provided personal opinions regarding signal timing. Some described air pollution or making drivers angry as unintended consequences of changing the signal timing to favor pedestrians. This suggests a need for further input from additional perspectives, such as environmental health and drivers, to fully understand the advantages and disadvantages of changing signal timing. By including opportunities for respondents to provide qualitative responses, other issues not initially considered by the study team surfaced as pedestrian safety concerns.

Pedestrian safety is a public health issue. Neighborhoods that support active transportation have safe and timely street-crossing experiences; and controlled traffic all contribute to a healthy neighborhood and healthy residents. This exploratory study investigated the pedestrian experience and barriers associated with crossing Rainier in the focus neighborhoods of Rainier Beach and Columbia City.

Study findings support the hypothesis that traffic signals in the lower- income focus neighborhoods were more likely to favor vehicular traffic than in the higher-income comparison neighborhood. Pedestrian delays exceeding 30 seconds are associated with non-compliance and injury; nearly 75% of all pedestrian delays across the focus and comparison study sites exceeded 30 seconds.

Residents and pedestrians in Columbia City and Rainier Beach identified signal timing as a primary barrier to crossing Rainier. Other barriers identified by pedestrians include traffic, personal safety, and the built environment. Pedestrian experiences varied by neighborhood and action steps should be tailored to address the specific needs and concerns of each community.

By adopting a public health lens, we find that there are many strategies to address pedestrian safety. Our primary recommendations for enhancing pedestrian safety in Rainier Valley include signal timing improvements; traffic infrastructure and enforcement; and community development. Collaboration with government and community partners is essential to facilitate positive and sustainable change in the Columbia City and Rainier Beach neighborhoods.

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