Evaluation of Red Light Cameras in Texas Using a Cost-Impact Analysis

AP Research

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Introduction

Red light cameras (RLCs) have been a controversial topic for cities since the 1990s, due to the fact many believe they do not actually serve their purpose of reducing accidents, rather are implemented as a way to generate revenue at a low cost. Red light cameras were implemented around 1990 to help alleviate the frequency of intersection collisions, however they came with a cost. They were implemented because they cost less than manned enforcement, and could run 24/7. Red light cameras were installed into cities by contractors, who own the cameras. States drove up ticket prices for running red lights to pay for the cost of upkeep of the cameras. Recently filed lawsuits against cities has caused them to rethink their viability and cost-effectiveness.

Literature Review

Retting (1999) who focuses on transportation planning, and his team found 5% more people favored red light cameras after they were installed based on a telephone survey in Oxnard, California. People adapt, accept and see the purpose of the cameras after they experienced it, showing how people were somewhat paranoid of the cameras so much that they changed their driving habits. Overall, his research found that red light cameras reduced red light violation rates after the red light camera program had begun, even at non-equipped intersections, meaning they are a good deterrent.

In another study done by Retting (2008), he found that the strong effects of red light cameras after having increased the duration of yellow signal timing provides evidence that provisional of adequate yellow timing may not eliminate the need for or the potential benefits of red light camera enforcement. He adds another system, yellow signal timing, to consider and

found that red light cameras have also increased other aspects of traffic flow. Ghoghi, Zhou, Wasilefsky (2015), researchers at Auburn University who specialize in civil engineering, researched the effect of red light cameras on capacity of signalized intersections, and found that drivers are more likely to brake sooner during the yellow or all red intervals, causing reduction of usable amount of time and a decline in the intersection capacity.

However, in Bochner and Walden's (2010) research they concluded that red light cameras "may or may not reduce total crashes, but rarely result in a substantial increase," showing that red light running is not the main cause of accidents. They did find that the accidents regarding red light running will decrease with the implementation of red light cameras, but it does not reduce the amount of accidents a whole lot.

Fleck and Smith (1999), where they took data from a San Francisco red light camera pilot program, they found that there was a "citywide reduction in collisions and injuries caused by red light violations" after red light cameras had been installed. They had similar findings as Retting- red light cameras do improve the overall safety of the city. This may because "drivers cannot always keep track of the monitored locations," as they do move the cameras around (Fleck & Smith, 1999). This is the main reason red light cameras are deemed to be very effective, they cause the spillover effect, as drivers start to change their driving habits and remember to not run red lights, and if they do, it could be costly. Retting (1999) also found that changes in driver compliance with red lights were not just changed at intersections with cameras, rather compliance was enhanced at nearby intersections without cameras, which he based off of the "experience of the three non-camera sites." Cameras were proven to not only affect the area they were in, instead also affected intersections that did not have any cameras. This study shows how

cameras are effective to reduce red light violations, along with all the other studies, but the effectiveness in this study does not mean they are cost effective.

Current Gap of Knowledge

In past studies, researches have based effectiveness solely on the fact if red light cameras reduced the number of accidents at the intersections, without taking into account the cost of collisions and the cameras themselves. As previously mentioned, red light cameras have been used as a deterrent to running "orange" lights even if they are not at every intersection. Many people learn to not run red lights due to the fact they if they do it would cost them a great deal of money. And because of this, researchers have found that red light cameras are effective because they do reduce collisions, however that does not mean they are an effective cost solution, for both citizens and the city itself.

Numerous studies have shown RLCs are effective at reducing intersection collisions. Unfortunately, there are few studies that take cost considerations into account when measuring their impact. Previous research has focused on a simple yes or no question answering if red light camera systems reduce intersection collisions, rather than taking into account the cost associated with the systems, including tickets. Although there are some studies that mention cost-effectiveness, they do not explore the full effect of cost considerations from both a city and citizen perspective.

Objective/Purpose

This study stems from interest of the cost impact of the cameras- many scholars agree that they are effective for reducing collisions, however they have yet to look into the cost that goes into collisions and the cameras themselves. This new idea can be used by cities as a new

way to evaluate the effectiveness of the cameras from a financial perspective. In this study, effectiveness will be analyzed both quantitatively and qualitatively with the use of data provided from the California and Texas government websites. The cost of each component will contribute the to the annual cost each city uses to avoid injury. Furthermore, intersection demographics will be considered qualitatively when measuring the effect of preventing an injury.

The goal of this study is to evaluate red light cameras to find out if they are cost-effective due to the lack of scholarship with the purpose of finding out if the cost of the cameras, maintenance, collisions, injuries, fatalities and tickets are cost-beneficial. This study will use the World Health Organization (WHO) threshold of cost-effectiveness to establish if the systems are cost-beneficial. The Institute for Clinical and Economic Review's (ICER) budget impact threshold will also be used to evaluate cost-impact.

The goal of red light cameras, the same as other traffic enforcement is to reduce the amount of crashes and the severity of them (Retting, 1999). Red light cameras should be treated as other health related policies such as helmet laws, seat belt laws, analogous to anti-smoking campaigns, as all these programs strive to reduce injuries that result hospitalizations and death. They are also analogous to medical devices and pharmaceuticals, where the goal in implication is to reduce injuries and death, which is why this study uses the WHO and ICER thresholds to determine cost-impact on both an individual basis, as well as a societal basis (Appendix G).

Hypothesis

The implementation of camera systems will reduce intersection collisions, so cost of the cameras will be under the WHO and ICER budget impact thresholds when only considering costs for cities, therefore considered cost-effective. On the other hand, the cost of systems, as

well as tickets, will be over the WHO and ICER budget threshold when considering the costs for citizens and the city, and will be considered not cost-impactful.

Furthermore, this study predicts that the cost-impact will be greater at larger intersections because there will be more traffic flow, and have a greater chance to reduce a collision and injury. This is because larger roads have greater speeds so the damage during a collision is greater, and people are less likely to stop at a red light when they are at a higher speed.

Design

The design of this study is a before and after comparison of the impact of RLCs. The data analyzed is from the state of Texas public website, where they have pre- and post-activation sites of red light cameras, citing the number of collisions that happened before and after installation, as well as how many tickets were issued at each red light camera intersection. There is a total of 13 cities that could be analyzed, however this study only will analyze 4 of the 13.

The Texas data set included pre- and post- activation data of 13 Texas cities: Amarillo, Austin, Bedford, Denton, Fort Worth, Frisco, Garland, Mesquite, Port Lavaca, Richardson, Richland Hills, University Park and Willis. In this study, ‘data’ refers to data that was taken regarding street demographics, the number of each specific crash that happened at each participating intersection and tickets issued from each camera during the reporting period.

Pre-activation data was taken 18 months prior to the installation of a red light camera at the intersection. Post-activation data was reported from July 1, 2016 — June 30, 2017. This makes data very current, which is important because the number of injuries and fatalities should be more reflected on current technology of cars; they are generally safer now with the

technological advances including better collision prevention technology (Consumer Reports, 2018).

The data provided from the Texas Government was put into spreadsheets for analysis (Appendix A-D).

Methods

Only 4 Texas cities were chosen out of the 13 to focus the study on similar cities of Ventura County. The Texas cities were compared to Oxnard, Ventura, Simi Valley and Thousand Oaks, all of which lie in the Ventura County. The primary factor that determined which cities were chosen was based on the mean transportation time to work compared to the cities of Ventura County, since commuting to work is the primary time where people consistently drive. Another factor that was considered was median income per household, and the number of people per household. The median income per household was important in matching cities together because it gives perspective for how much a ticket costs relative to the income a household makes. Tickets are independent of income, similar to gas prices, meaning the ticket costs the same for someone who makes a lot and a person who makes very little. The number of people per household was another important factor because it gives an idea on how many cars each household owns and contributes to the amount of people on the road. The data for these factors was obtained from the 2010 census. Ultimately, the cities chosen were Frisco, Mesquite, Denton and Fort Worth.

Comparison of Ventura County Cities to Texas Cities					
City	Mean value time to work (minutes) (2012-2016)	Land area in square miles (2010)	Medium income/household (in 2016 dollars)	Number of households (2012-2016)	Persons/household (2012-2016)
Denton, TX	24	87.95	$50,487	44,926	2.62
Ventura, CA	24.6	21.66	$70,541	40,653	2.64
Oxnard, CA	24.8	26.89	$61,709	50,839	4
Thousand Oaks, CA	25.8	55.03	$101,045	45,873	2.76
Fort Worth, TX	26.8	339.82	$54,876	279,426	2.86
Simi Valley, CA	29.5	41.48	$91,196	42,209	2.97
Frisco, TX	29.7	61.8	$117,642	48,664	2.99
Mesquite, TX	30.7	46.02	$50,804	47,086	3.04

Figure 1: Chart shows the Texas cities chosen with comparison to Ventura County, California cities. It is organized in ascending order of the mean value of commute to work, as that was the main factor for which cities were chosen. The color of each city corresponds to a Texas, California city pair that was selected to participate in this study. (US Census)

Even though the land area is much larger in Texas, they have similar driving conditions as the cities in California, just at a larger scale, with more space in between place to place. Although it appears that Frisco and Thousand Oaks are far away from each other on the table, they were paired together because they both had the highest median income of their county by a lot. The median income was included and provided another perspective in drawing conclusions between the cities. Furthermore, the Texas cities pair up very well to the Ventura County cities and there are no jumps or overlaps from the pairing on the chart, as it matches Texas to California city in ascending order starting with Denton-Ventura all the way to Mesquite- Simi Valley.

Oxnard was a perfect match for Fort Worth because Oxnard city has been researched on multiple times, and is one of a small group of cities that has previous research on it. It also has a 2 minute difference between the mean value time to work. The large sample size of cameras, 35, gave more accurate data because it minimizes large variances.

The pre-activation data was taken 18 months prior to the installation of the cameras, meaning the reporting period was 18 months, longer than the 12 months of data collected after installation. To deal with this, the number of collisions and injuries of the pre-activation data was divided by 1.5 to account for the longer reporting period. By dividing by 1.5, both reporting periods were 1-year time periods of data collection, allowing for comparable data between the pre- and post-activation data.

Cost Considerations

This study uses cost considerations from multiple sources to evaluate the cost-impact of red light cameras. This study will consider the perspectives of both the municipality and the citizens. The municipality costs include the cost of equipment, maintenance, property damage and hospitalization costs. The costs for citizens included the previously mentioned, as well as the cost of tickets. The cost of tickets pay for the cameras, the cost of tickets are used to reduce injuries and fatalities, meaning they are indirectly a part of the system cost.

It was found that the cost the camera systems (equipment costs) were about $60,000, and about $25,000 to install (CDC, 2015). This totals up to $85,000 per intersection. In addition, the average contract for a system was 5 years, meaning the total cost of $85,000 was divided by 5 to have the cost per year of $17,000 (Redflex, 2003).

The cost for monthly maintenance was $5000, which total ups to $60,000 per year per intersection (CDC, 2015).

The cost for property damage during a collision was found to be around $3200 (RMIIA, 2015).

Injury and fatality costs only considered the cost of hospitalization. The cost for an injury and fatality was found to be around $20,000, as hospitalization costs are around $5,000, and average hospitalization stays are 4 nights (International Federation of Health Plans, 2015). Fatalities and injuries are approximately the same amount as some people are pronounced dead at the scene, and do not have to go to the hospital to be treated.

Lastly, the cost of tickets from the cameras were found to be $75 (Fort Worth, 2018). It is important to note that the cost of tickets at automated enforcement are significantly cheaper than the cost of tickets of manned enforcement; the cost of a ticket from an officer is over $150 (Texas Driving University, 2017).

Marseille (2014), who focuses on the empirical and modeled assessment of the cost-effectiveness of services, programs and policies addressing global health, established that the threshold for cost effectiveness is $50,000 — $150 000 per QALY gained for the World Health Organization. This is consistent with the thresholds of the Institute for Clinical and Economic Review. Thresholds provide a recognized benchmark for researchers to compare their cost impact with, allowing researchers to measure effectiveness from an economical and financial standpoint.

Results & Discussion

Average Cost Considerations for Municipality (4)							
Before	Cost	# of	Total	After	Cost	# of	Total
Camera	$17,000	0	$0		$17,000	10.75	$182,750
Camera Maintenance	$60,000	0	$0		$60,000	10.75	$645,000
Vehicle Cost/Collision	$3,200	19.2	$61,440		$3,200	4.25	$13,600
Injuries	$20,000	16	$320,000		$20,000	7	$140,000
Fatalities	$20,000	0.33	$6,600		$20,000	0	$0
TOTAL			**$388,040**				**$981,350**

Average Cost Considerations for Municipality & Citizens (4)							
Before	Cost	# of	Total	After	Cost	# of	Total
Camera	$17,000	0	$0		$17,000	10.75	$182,750
Camera Maintenance	$60,000	0	$0		$60,000	10.75	$645,000
Vehicle Cost/Collision	$3,200	19.2	$61,440		$3,200	4.25	$13,600
Injuries	$20,000	16	$320,000		$20,000	7	$140,000
Fatalities	$20,000	0.33	$6,600		$20,000	0	$0
Tickets	$75	0	$0		$75	51,322	$3,849,150
TOTAL			**$388,040**				**$4,830,500**

Averages of all 4 Cities

The cost considerations for the 4 municipalities averaged to be $981,350. This suggests that the impact of RLCs are too costly due to the ICER's threshold of $915,000,000 for a new health system. If the cost for 1 city is already close to 1 million dollars, that means only 1000 cities in the United States can use RLCs.

It was found that there are 270 cities larger than Ventura, so the average cost considerations were multiplied by 270 in order to evaluate the cost-impact of RLCs on a country wide level (Biggest, 2017). The cost of RLCs without taking into account tickets would cost

$264,964,500, which is below ICER's threshold for a new system that impacts health. This suggests that if RLCs were to be implemented to the top 270 largest cities, they would be high impact relative to the money spent. However, when accounting for citations, the cost for all 270 cities would be $1,304,235,000. The cost impact greatly exceeds the ICER's budget impact threshold for a new system that impacts health, suggesting that the implementation of RLCs is not an ideal system to be implemented.

Impact on individual cities varied based on size and frequency of intersection collisions before and after installation.

Denton (Appendix A)

The city of Denton had an extreme case, where the cost of the camera and maintenance was actually lower than the cost before activation. Because of this, it suggests that the city of Denton was able to introduce cameras at the most needed intersections, and the cameras proved beneficial at reducing accidents, as well as reducing costs. Before activation, the cost considerations totaled up to $192,6000, while after activation, the cost considerations totaled up to $154,000. With the introduction of red light cameras, Denton was able to save $38,600 dollars due to the elimination of injuries and collisions.

However, when taken into account tickets from the societal perspective, the cost-benefit of the cameras is decreased. Due to the 7,838 tickets issued from the 2 camera systems combined, the cost consideration total from a societal perspective was increased to $741,850. This jump of cost is over 4 times more the cost considerations without the impact of tickets, ultimately causing the cost per injury avoided to increase.

The cost to reduce about 9 injuries was about $549,250, which in turn comes out to a cost of $61,028 per injury avoided when taking account the ticket costs. According to the ICER threshold, the installation of red light camera systems in Denton, at the 2 intersections evaluated, is cost-effective and has an intermediate value because to avoid one injury, it costs between $50,000-$150,000. On the other hand, the cost to reduce injury regarding municipality, would be highly cost effective because it is on the negative range, as it is less expensive than the cost associated before the cameras.

Fort Worth (Appendix B)

Before activation, the cost considerations totaled up to $1,175,856, while after activation, the cost considerations totaled up to $3,268,200. Even though the introduction of RLCs reduced the number of collisions, injuries and fatalities, they spent $2,110,344 to reduce collisions, injuries and fatalities, more than before installation.

The cost to reduce about 20 injuries was roughly $2,110,344, which in turn comes out to a cost of $105,517 per injury avoided for the municipality. The cost to reduce 1 fatality was $2,110,344.

However, when taking into account tickets from a societal perspective, the cost-impact of the cameras greatly decreased. Due to the 147,351 tickets issued from the 35 systems, the cost considerations increased to $14,337,525. This is over 4 times the cost when considering the cost for the number of tickets issued.

The cost to reduce 21 injuries and fatalities combined was about $13,161,669, which in turn comes out to a cost of $626,746 per injury & fatality avoided when considering ticket costs. The cost of reduce 1 death was $13,161,669. According the ICER threshold, the installation of

RLC systems in Fort Worth, at the 35 intersections evaluated, is only cost-effective for the municipality perspective. Because the cost per injury avoided was $105,517, RLC systems are cost effective, and hold an intermediate value.

The results of Fort Worth were more extreme than the results of Denton when considering the cost of tickets for the citizens. While the cost considerations were almost 4 times the amount when considering tickets in Denton, the cost considerations of Fort Worth were 12 times the amount when considering tickets. However, Fort Worth was not as extreme as Frisco, where the cost was 77 times more when considering tickets.

In Fort Worth there were some intersections that may have not needed RLCs due to the little to none amount of collisions. For example, the intersection of E. Rosedale & S. Handley Dr. may have not needed a system because there were no accidents there to begin with, and thus the city and the citizens were paying for something that may have not been needed. Furthermore, there were 2574 tickets issued at that intersection that had no collisions both before and after installation. Trinity Blvd. & State Hwy 360 had no intersection collisions before as well, yet 3927 tickets were issued.

The intersection of Lancaster Ave & Sandy Ln was another that may not have needed RLCs, due to 0 collisions to begin with. If there are no collisions to begin with, the amount of collisions after can only increase or remain the same. In fact, they had an increase of rear end collisions, similar to what Fleck & Smith (1999) found.

In short, the cost-impact could be increased if the placement of cameras are more selective.

Frisco (Appendix C)

In Frisco, it may have been unnecessary to introduce cameras because of the low intersection collision rates with the 2 intersections studied. The city of Frisco spent over 3 times the amount of money to eliminate collisions. They reduced 2 injuries within the 2 intersections with the introduction of red light cameras. Furthermore, the city of Frisco, including the citizens, spent over 77 times the amount of cost before the cameras to reduce 2 injuries. The cost to reduce 2 injuries was $3,394,894, which comes out to $1,697,447 per injury avoided, clearly exceeding the $150,000 ICER threshold.

The intersection of State Highway 289 and Lebanon Road has a higher speed limit of 45 mph, and SH 289, the primary street, is on the state highway systems, indicating that many people that use the primary street are commuting to and from work from another city. The camera systems at this intersection issued a total of 32,902 tickets during the reporting time period of one year. The cost of tickets alone from this intersection was $2,467,650 out of the $3,439,150 from both intersections that were investigated.

The intersection of State Highway 289 and Lebanon Road was a quality intersection to evaluate because of the consistent demographics of both the pre- and post- activation data. The yellow signal timing was the same for both reporting periods, 4.3 / 4.3 seconds. The yellow signal timing was not altered to allow for a longer period of yellow time to pass through the intersection, so the results of this intersection are strict dependent of the red light cameras. In addition, consistent yellow signal timing did not affect the number of tickets issued and tickets were not theoretically decreased with a longer yellow time. The number of turn lanes and through lanes stayed consistent between both reporting periods. The only demographic that was

altered was the red signal timing of 2.1 /2.1 beforehand, to 2.2 / 2.2 after installation, which has minimal effect on the reduction of crashes.

A potential more cost impactful option for Frisco may have been to increase the yellow signal timing, similar to what Ghorghi, Zhou and Watkins (2017) suggest as an alternative option to reduce intersection collisions. Increasing yellow signal timing would have a very minimal cost since there would be no equipment that would be needed to change the timing, other than a traffic engineer, which would not cost nearly as much as red light camera systems.

Mesquite (Appendix D)

The cost considerations before cameras were $139,200, compared to $331,200 after installation without considering the number of citations and their costs. This results in 5 injuries reduced at a cost of $192,000, or $38,400 per injury avoided. This is less than the WHO threshold for new systems that impact health. RLCs for the municipality of Mesquite would fall under 'high value' according to the WHO threshold (2014).

However, similar to the other 3 cities, the cost considerations accounting for citation costs drastically increases. The total cost considerations were $803,550 when accounting for citations, meaning 5 injuries were reduced at $664,350. The cost to reduce one injury was $132,870, which is within the WHO threshold.

The reason why Mesquite was under or within the thresholds was because all the cameras were placed at intersections that had collisions before installation, meaning that number of collisions could actually go down. In addition, Mesquite as a whole was a solid city to analyze because of the consistent demographics between the pre- and post-activation. The only variable to change was the installation of RLCs, meaning the data was only dependent on such.

Conclusions

Post implementation of red light cameras reduced the number of accidents in all of the cities evaluated in this study. They are a cost-effective tool in reducing hospitalization and death due to injuries when ticket cost is not factored into cost considerations. Red light cameras exceed budget impact thresholds when cost of tickets is included.

Limitations

Due to secondary data collection, the data collected could have been biased because the Texas government may only include positive outcome cities, where red light cameras reduced red light related intersection collisions, on their website. In addition, there were no controls on the yellow signal timing, as well as other demographics, making it hard to determine if changes of driving behavior were solely based on the red light cameras. However, even if variable were consistent, based on scholarship, there should not have been much of a difference (Retting, 1999).

The cost of the systems and maintenance were assumed fixed amongst cities, however there should not be much variation between contracts of different cities. But it is important to consider that each city creates their own contract with the red light camera company operators regarding costs of maintenance and the system itself.

This study does not account for the portion of ticket proceeds that went back to pay for the cameras or into the general city budget. As a result, the cost of tickets were assumed to be charged to citizens and were not further calculated.

This study did not take into consideration the spillover effect, and how non red light camera intersections may see a “positive, areawide effect” as Llau & Ahmed (2013) suggest.

Similar to this study, the researchers from the Florida International University, also did not account for the spillover effect.

This study only accounted for property damage and hospitalization costs, so insurance rates, funeral services and loss productivity were not included. Although, if they were included, they would be very negligible towards cost considerations.

Also, this study drew country conclusions from just suburban metro high density cities, which does not make up the entirety of the US. However, RLCs are found to be installed in high density areas, so they can patrol more people in a smaller area (Fleck & Smith, 1999).

Further Research

It would be beneficial for future studies to conduct this research based on a larger population of cities that have both pre- and post-activation data, as this study only evaluated metro suburban high-density areas. In this study, only 4 cities were utilized in order to draw conclusions. By increasing the same size of a future study, there will be a greater likelihood of being more accurate when drawing generalized conclusions. Additionally, it would create more accurate conclusions when evaluated to the ICER threshold on a country wide scale.

If a similar study were to be conducted again in the future, researchers should investigate cost-impact of red light camera systems including all intersections of a city, even intersections without systems, to consider the impact on the spillover effect, as mentioned by other articles. This way, there will be new research that considers the spillover effect, as well as cost considerations, as this study investigated.

In addition, similar studies should conduct this type of analysis on Oxnard, California because of the abundance of scholarship analyzing the effectiveness of red light cameras there.

Also, it would be interesting to see if 25 years later after installation, if the cameras have the same effect. And if it has changed, studies should evaluate and draw conclusions on the reasons for the change.

Griffith (2005), who works with the U.S Department of Transportation, found that his data was similar to studies that were like his, however the positive effects were slightly lower than the other studies. This may be because cost considerations are dismissed by decision makers, and they revert to political or organizational interests to decide if red light cameras should be implemented (Marseille, 2014). This brings the question on if evaluation can be furthered looked into with the cost-benefit perspective.

As this study was not a study focused on the politics and revenue involved, future studies should consider new aspects, like political influence.

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Appendices

Appendix A: Denton

Denton Cost Considerations for Municipality							
Before	Cost	# of	Total	After	Cost	# of	Total
Camera	$17,000	0	$0		$17,000	2	$34,000
Camera Maintenance	$60,000	0	$0		$60,000	2	$120,000
Vehicle Cost/Collision	$3,200	6	$19,200		$3,200	0	$0
Injuries	$20,000	8.67	$173,400		$20,000	0	$0
Fatalities	$20,000	0	$0		$20,000	0	$0
TOTAL			**$192,600**				**$154,000**

Denton Cost Considerations for Municipality & Citizens							
Before	Cost	# of	Total	After	Cost	# of	Total
Camera	$17,000	0	$0		$17,000	2	$34,000
Camera Maintenance	$60,000	0	$0		$60,000	2	$120,000
Vehicle Cost/Collision	$3,200	6	$19,200		$3,200	0	$0
Injuries	$20,000	8.67	$173,400		$20,000	0	$0
Fatalities	$20,000	0	$0		$20,000	0	$0
Tickets	$75	0	$0		$75	7838	$587,850
TOTAL			**$192,600**				**$741,850**

Appendix B: Fort Worth

Fort Worth Cost Considerations for Municipality							
Before	Cost	# of	Total	After	Cost	# of	Total
Camera	$17,000	0	$0		$17,000	35	$595,000
Camera Maintenance	$60,000	0	$0		$60,000	35	$2,100,000
Vehicle Cost/Collision	$3,200	63.33	$202,656		$3,200	16	$51,200
Injuries	$20,000	47.33	$946,600		$20,000	27	$540,000
Fatalities	$20,000	1.33	$26,600		$20,000	0	$0
TOTAL			**$1,175,856**				**$3,286,200**

Fort Worth Cost Considerations for Municipality & Citizens							
Before	Cost	# of	Total	After	Cost	# of	Total
Camera	$17,000	0	$0		$17,000	35	$595,000
Camera Maintenance	$60,000	0	$0		$60,000	35	$2,100,000
Vehicle Cost/Collision	$3,200	63.33	$202,656		$3,200	16	$51,200
Injuries	$20,000	47.33	$946,600		$20,000	27	$540,000
Fatalities	$20,000	1.33	$26,600		$20,000	0	$0
Tickets	$75	0	$0		$75	147351	$11,051,325
TOTAL			**$1,175,856**				**$14,337,525**

Appendix C: Frisco

Frisco Cost Considerations for Municipality							
Before	Cost	# of	Total	After	Cost	# of	Total
Camera	$17,000	0	$0		$17,000	2	$34,000
Camera Maintenance	$60,000	0	$0		$60,000	2	$120,000
Vehicle Cost/Collision	$3,200	1.33	$4,256		$3,200	0	$0
Injuries	$20,000	2	$40,000		$20,000	0	$0
Fatalities	$20,000	0	$0		$20,000	0	$0
TOTAL			**$44,256**				**$154,000**

Frisco Cost Considerations for Municipality & Citizens							
Before	Cost	# of	Total	After	Cost	# of	Total
Camera	$17,000	0	$0		$17,000	2	$34,000
Camera Maintenance	$60,000	0	$0		$60,000	2	$120,000
Vehicle Cost/Collision	$3,200	1.33	$4,256		$3,200	0	$0
Injuries	$20,000	2	$40,000		$20,000	0	$0
Fatalities	$20,000	0	$0		$20,000	0	$0
Tickets	$75	0	$0		$75	43802	$3,285,150
TOTAL			**$44,256**				**$3,439,150**

Appendix D: Mesquite

Mesquite Cost Considerations for Municipality							
Before	Cost	# of	Total	After	Cost	# of	Total
Camera	$17,000	0	$0		$17,000	4	$68,000
Camera Maintenance	$60,000	0	$0		$60,000	4	$240,000
Vehicle Cost/Collision	$3,200	6	$19,200		$3,200	1	$3,200
Injuries	$20,000	6	$120,000		$20,000	1	$20,000
Fatalities	$20,000	0	$0		$20,000	0	$0
TOTAL			**$139,200**				**$331,200**

Mesquite Cost Considerations for Municipality & Citizens							
Before	Cost	# of	Total	After	Cost	# of	Total
Camera	$17,000	0	$0		$17,000	4	$68,000
Camera Maintenance	$60,000	0	$0		$60,000	4	$240,000
Vehicle Cost/Collision	$3,200	6	$19,200		$3,200	1	$3,200
Injuries	$20,000	6	$120,000		$20,000	1	$20,000
Fatalities	$20,000	0	$0		$20,000	0	$0
Tickets	$75	0	$0		$75	6298	$472,350
TOTAL			**$139,200**				**$803,550**

Appendix E: All Cities Combined

Total Cost Considerations for Municipality (4)							
Before	Cost	# of	Total	After	Cost	# of	Total
Camera	$17,000	0	$0		$17,000	43	$731,000
Camera Maintenance	$60,000	0	$0		$60,000	43	$2,580,000
Vehicle Cost/Collision	$3,200	76.7	$245,440		$3,200	17	$54,400
Injuries	$20,000	64	$1,280,000		$20,000	28	$560,000
Fatalities	$20,000	1.33	$26,600		$20,000	0	$0
TOTAL			**$1,552,040**				**$3,925,400**

Total Cost Considerations for Municipality & Citizens (4)							
Before	Cost	# of	Total	After	Cost	# of	Total
Camera	$17,000	0	$0		$17,000	43	$731,000
Camera Maintenance	$60,000	0	$0		$60,000	43	$2,580,000
Vehicle Cost/Collision	$3,200	76.7	$245,440		$3,200	17	$54,400
Injuries	$20,000	64	$1,280,000		$20,000	28	$560,000
Fatalities	$20,000	1.33	$26,600		$20,000	0	$0
Tickets	$75	0	$0		$75	205,289	$15,396,675
TOTAL			**$1,552,040**				**$19,322,075**

Appendix F: Average of All Cities

Average Cost Considerations for Municipality (4)							
Before	Cost	# of	Total	After	Cost	# of	Total
Camera	$17,000	0	$0		$17,000	10.75	$182,750
Camera Maintenance	$60,000	0	$0		$60,000	10.75	$645,000
Vehicle Cost/Collision	$3,200	19.2	$61,440		$3,200	4.25	$13,600
Injuries	$20,000	16	$320,000		$20,000	7	$140,000
Fatalities	$20,000	0.33	$6,600		$20,000	0	$0
TOTAL			**$388,040**				**$981,350**

Average Cost Considerations for Municipality & Citizens (4)							
Before	Cost	# of	Total	After	Cost	# of	Total
Camera	$17,000	0	$0		$17,000	10.75	$182,750
Camera Maintenance	$60,000	0	$0		$60,000	10.75	$645,000
Vehicle Cost/Collision	$3,200	19.2	$61,440		$3,200	4.25	$13,600
Injuries	$20,000	16	$320,000		$20,000	7	$140,000
Fatalities	$20,000	0.33	$6,600		$20,000	0	$0
Tickets	$75	0	$0		$75	51,322	$3,849,150
TOTAL			**$388,040**				**$4,830,500**

Appendix G: Thresholds

Institute for Clinical and Economic Review (2016)

Potential Budget Impact threshold 2017-2018

Item	Parameter	2017-2018 Estimate	Source
1	Growth in US GDP, 2017 (est.) +1%	3.20%	World Bank, 2016
2	Total personal medical health care spending	$2.71 trillion	CMS NHE, 2016
3	Contribution of drug spending to total health care spending	17.7%	CMS NHE, 2016; Altarum Institute, 2014
4	Contribution of drug spending to total health care spending	$479 billion	Calculation (Row 2 x Row 3)
5	Annual threshold for net health care cost growth for ALL drugs	$15.3 billion	Calculation (Row 1 x Row 4)
6	Average annual number of new molecular entity approvals	33.5	FDA, 2016
7	Annual threshold for average cost growth per individual new molecular entity	$457.5 million	Calculation (Row 5 ÷ Row 6)
8	Annual threshold for estimated potential budget impact for each individual new molecular entity	$915 million	Calculation (doubling of Row 7)

ICER

Proposed modified MCDA: application to rating of long-term value for money

Other benefits/contextual considerations average score	Associated incremental cost-effectiveness ratio used as threshold for final value-based price benchmark
1	$50,000 per QALY
2	$75,000 per QALY
3	$100,000 per QALY
4	$125,000 per QALY
5	$150,000 per QALY