

An Expected Value Comparative Analysis Study on First Responder and Fire Protection Policies, Services, and Products in the United States

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ABSTRACT: The present study conducted expected value analysis on 12 fire protection policies, services, and products in the United States. The cost of the policy, product, or service was compared with the expected benefit (value), which was determined by multiplying the payoff amount with probability. Cost benefit analysis was used on eight fire protection products, policies or services, and cost effective analysis was used on four fire protection products, policies, or services. Three fire protection products, policies, or services (fire resistance construction materials, volunteer fire departments, and fire extinguishers) were found to be cost beneficial while five fire protection products, policies, or services (emergency medical memberships, fire sprinkler systems, fire alarms, fire insurance and fire department medical calls), were not. Expected value equations show that fire protection for the most part does not provide economic value, yet the industry is protected by fire protection requirement laws. Cost effective analysis was used to determine cost per life saved for paramedic care, automated external defibrillators, helicopter emergency medical services, and smoke alarms. Paramedic care was found to be most cost effective, followed by automated external defibrillators, helicopter emergency medical services, and smoke alarms.

KEYWORDS: Fire protection services, expected value, cost benefit analysis, cost effective analysis, and expected benefit.

INTRODUCTION

In 2014, the total cost of fire protection and damage in the United States was \$328.5 billion, which was 1.9 percent of the U.S. Gross Domestic Product (GDP) (Zhuang, Payyappalli, Vineet and Lukasiwicz, 2017). Zhuang et al. (2017) defined *the total cost of fire* as the collective of all net expenditure on fire protection and all net losses due to fire incidents (p. 7). Fire protection expenditures totaled \$273.1 billion (83.1 percent of total), and losses amounted to \$55.4 billion (16.9 percent of total). Comparing the two, fire protection expenditures cost approximately six times more than the cost of fire damage. Further, the expenditures associated with increased building construction costs to improve fire safety (\$57.4 billion) were greater than the losses caused by actual fire damage (\$55.4 billion)

With regard to fire protection, the National Fire Protection Association reported that the number of building fires has fallen 54 percent over the past 40 years (Haynes, 2017). Approximately 1,098,000 building fires occurred in 1977 compared to only 480,500 in 2009. Building fires have ranged between 475,500 and 501,500 per year over the past decade.

Further, according to McChesney (2015), firefighters responded to 487,500 structure fires across the United States in 2013, which means each of the nation's 30,000 fire departments saw just one fire every 22 days, on average. Yet, while structure fires have declined, the amount of money cities paid for local fire services has more than

doubled from 1987 to 2011 to \$44.8 billion, adjusted for inflation. The National Fire Protection Association reported that the increase in fire department costs was due to increases in staff, salaries, overtime pay and retirement as well as health benefits.

Perry (2015) reported that over the last 20 years, building fires in the United States declined by about 50 percent while the number of career firefighters increased by more than 50 percent. Many of today's newer buildings have been constructed with fire-resistant materials. Also, because laws now mandate sprinkler systems, when a fire breaks out, the sprinkler systems will often extinguish the flames before the firefighters show up, thereby reducing the demand for fire fighters. However, fire sprinkler systems have not provided economic value once the cost of the sprinkler system, net savings in fire damage, probability of a fire, and the fact that fire department budgets have increased, not decreased.

Roughly 50 percent fewer fires have occurred compared to 40 years ago; however, 50 percent more people are being paid to fight them. According to McChesney (2015), city efforts to reduce the firefighting operations in line with the reduced demand for their services have failed against the powerful fire fighters unions. Cities should replace career firefighters with volunteer firefighters, but unions often forbid members from serving as volunteer firefighters, under penalty of fines or expulsion. In order to stay busy, fire departments have expanded into neighborhood

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beautification, gang intervention, substitute-teaching, and other downtime pursuits (McChesney, 2015).

Home Fire Insurance Policy

Fire insurance does not provide economic value once the cost of the policy and the net savings from fire damage as well as the probability of a fire are taken into consideration. The National Fire Protection Agency (2017) reported that United States fire departments responded to 358,500 home structure fires that caused \$6.7 billion in fire damage. According to Statista (2018), there were 127.59 million households in the United States making the probability that one's home will catch on fire during any given year 1 in $2,800$ ($358,000$ home fires/ $127,590,000$ households = 0.0028). The average annual cost per household for fire damage is \$52.51 ($\6.7 billion/ 127.59 million). According to Value Penguin (2019), the average annual cost of a homeowner's fire insurance policy was \$1,083 nationwide. Therefore, the average expected value of fire insurance policy would be 0.0484 ($\$52.51 / \$1,083$) so those who purchased a fire insurance policy receive on average a return of less than five cents (0.0484) for every dollar invested.

Home Fire Sprinklers

Home fire sprinkler systems do not provide economic value once the cost of a fire sprinkler system and the net savings from fire damage as well as the probability of a fire are taken into consideration. The United States Fire Administration (2019) found that the average cost of fire damage in a house with and without fire sprinklers was \$2,170 and \$45,110, respectively. The average cost of installing home fire sprinkler systems was \$1.61 per square foot of space under sprinkler or around \$3,000 per house. Therefore, the expected annual cost of a \$3,000 fire sprinkler system that lasts 20 years before replacement would be \$150 ($\$3,000 / 20$ years). As discussed above, the probability of a house catching on fire is 1 in $2,800$. The expected value of a fire sprinkler system saving \$42,940 ($\$45,110 - \$2,170$) per fire would be $\$15.33$ ($\$42,940 / 2,800$) per year. The expected value of a \$3,000 fire sprinkler system would be \$306.60 ($\$15.33 * 20$ years). Those who purchase a fire sprinkler system receive an average return of 10.22 cents ($\$15.33 / \$150 = 0.1022$) for every dollar invested.

Emergency Medical Service Membership Program

Emergency medical service membership programs do not provide economic value once the cost of the membership program and the net savings from avoiding out-of-pocket expenses for hospital transport and paramedic response are taken into consideration. Some fire departments are charging fees for responding to emergency medical calls even when they do not include transporting someone to the hospital, which is a way to recover response costs. Residents can avoid the per-response fees by enrolling in the emergency medical service membership programs for 48 dollars a year.

Under the program, all permanent residents in the subscribing household can avoid out-of-pocket expenses for hospital transport and paramedic response. According to the National Fire Protection Agency (2018), 22,750,500 fire department medical aid calls were made in 2016. Roughly 60 percent of the calls included transporting someone to the hospital. The ride can cost as much as the emergency room visit, ranging between \$300 and \$1200 (approximately a \$750 average), tacking on fees for mileage and oxygen. This suggests that a 6.96 percent chance (based on a 327 million population) exists that someone living in a United States household will be assisted by an emergency medical service call in any given year ($22,750,500$ medical calls/ $327,000,000$ households). The \$48 membership would have an expected benefit of \$31.32 [$(\$750 * 60 \text{ percent}) * 0.0696$] and a return of 65.25 cents ($\$31.32 / \48) for every dollar invested into the medical service membership program.

Fire Extinguishers

Fire extinguishers do provide economic value once the total amount spent on fire extinguishers and the net savings from fire damage are taken into consideration. McSheffrey (2011) estimated that the 147,000 fires extinguished entirely by fire extinguishers reduced fire damage by \$5 billion in 2010. According to an IBIS World Report (2019) the United States fire extinguisher manufacturing industry reached revenues of \$1 billion in 2018. The \$5 billion annual benefit realized from fire extinguishers is \$4 billion more than the \$1 billion cost spent on fire extinguishers. The expected benefit of \$39.19 ($\5 billion/ $127,590,000$ households) exceeds the expected cost of \$7.83 ($\1 billion/ $127,590,000$). Those who purchase a fire extinguisher receive an average return of \$4.62 ($\$39.19 / \$7.83 = 4.62$) for every dollar invested.

Fire Alarm Subscription Services

According to the National Fire Protection Agency only 3.7 percent ($1,342,000$ out of $35,320,000$) fire department calls are fire related. United States fire departments responded to a total of 2,622,000 false alarms in 2016 (Statista, 2018). Thus, fire departments responded to twice as many false alarms as they did to actual fire-related calls. The cost per response to a false alarm has been estimated to be around \$1,000 per event, resulting in the estimated total cost of responding to false alarms to be around \$2.6 billion dollars. The \$2.6 billion cost of responding to a false alarm amounts to about 40 percent ($\$2.6$ billion/ $\$6.7$ billion in fire damage) of the total cost of fire damage. The economic benefit of a fire alarm and subscription service is essentially zero due to the almost universal availability of cell phones combined with 911 call centers. The annual false alarm economic cost per household is roughly \$20.55 ($\$2,600,000,000 / 127,590,000$ households), and the annual cost of the alarm and subscription service is around \$250 per year. Those who purchase a fire alarm service receive an average return of

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about eight cents ($\$20.55/\$250.00 = 0.0822$) for every dollar invested.

Volunteer Fire Fighters

The National Fire Protection Agency (2017) estimated that there were approximately 1,160,450 local firefighters in the United States in 2015. Of the total number of firefighters 345,600 (30 percent) were career firefighters and 814,850 (70 percent) were volunteer firefighters. According to the National Fire Protection Agency, 85 percent of the nation's fire departments are all or mostly volunteer, and communities with fewer than 10,000 residents are almost always served by volunteer departments.

According to the US Bureau of Labor Statistics (2018), firefighters earned a median salary of \$49,080 in 2017. However, a firefighter's salary can more than double with overtime pay and bonuses. For example, Dolan (2014) reported that average Los Angeles firefighters with overtime and bonuses factored earned over \$142,000 annually. Significant overtime costs are fueled by union-negotiated minimum-staffing levels that will often require four firefighters per engine to be on duty at all times regardless of workload (McChesney, 2015).

ZipRecruiter.com (2019) reported that the average annual pay for a volunteer firefighter was \$33,148 a year, and Indeed.com (2019) reported an average hourly rate for a volunteer firefighter at \$12.30 (\$25,584 annually), not including bonus and overtime. The median annual salary of a volunteer fire fighter ranges from \$15,932 to \$23,496 less than the median annual salary of a career fire fighter.

The annual salary cost of career fire fighters is \$16,962,048,000 ($345,600 * \$49,080$) and the annual salary cost of volunteer fire fighters is \$23,928,885,100 ($814,850 * \$29,366$ average volunteer firefighter salary) for a sum total of \$40,890,933,100 or \$320.49 ($\$40,890,933,100/127,590,000$) per household. United States Fire Departments could save on an annual basis an estimated \$10,148,889,600 ($345,600 * \$29,366$) annually by replacing all career fire fighters with volunteer fire fighters, which would be a sum total of \$240.94 ($\$30,742,043,500/127,590,000$) per household.

Fire Department Medical Calls

Zhuang, Payyappalli, Vineet and Lukasiewicz (2017) reported that the total cost of first responder and fire protection services amounted to \$273.1 billion in 2014?. The National Fire Protection Agency (2018) reported that 69 percent (24,265,500 out of 35,320,000) of the fire department calls were to provide mutual or medical aid often accompanying an ambulance, which would total \$188.439 billion ($\$273.1 \text{ billion} * .69$) or \$1,476.91 per household ($\$188,439 \text{ billion}/127,590,000$). Fire department medical calls provide almost no value since most communities already have ambulance services, whose staffs

are less expensive and more highly trained in medical aid (McChesney, 2015). According to the United States Bureau of Labor Statistics, in 2017 paramedics had a median salary of \$33,380, while career fire fighters earned a median salary of \$49,080. Firefighters on medical calls often arrive before the paramedics, but without the training and equipment to deal with many medical emergencies they seldom provide value. Further, Eng (2017) reported that fire departments have more firetrucks than ambulances, which makes little sense when one considers that most fire departments often receive 20 times more medical calls than fire calls. As a result, ladder fire trucks are responding to help those with minor injuries, which is not an effective use of resources. Ambulances, not fire trucks, are much better equipped to take the injured to the emergency room hospital. Recognizing the overlap, some cities have merged their fire and emergency medical services.

Fire Resistant Construction Materials

Flavelle (2018) reported that adding a fire-resistant roof, doors, vents, and gutters would increase building material costs for a home, but those costs would be offset by the use of fire-resistant fiber-cement siding, which costs less than half the price of the more commonly used cedar-plank siding. The average cost of building materials for typical home construction is about \$81,100, while the cost to build a wild-fire resistant home is around \$79,200. The \$1,900 savings ($\$81,100 - \$79,200$) amortized over a 40-year life span for the home would have an annual benefit of \$47.50 ($\$1,900/40$). The average annual cost per household for fire damage is \$52.51 ($\$6.7 \text{ billion in fire damage}/127.59 \text{ million households}$). The combined annual benefit on reduced risk of fire damage and home building cost savings totals \$100.01 ($\$52.51 + \47.50).

RESULTS

The present study conducted expected value analyses on 12 fire protection policies, services and products in the United States. The cost of the policy, product, or service was compared with the expected benefit (value), which was determined by multiplying the payoff amount with probability. Cost benefit analysis was used on eight fire protection products, policies or services while cost effective analysis was used on four fire protection products, policies or services. Three (fire resistance construction materials, volunteer fire departments, and fire extinguishers) fire protection products, policies, or services were cost beneficial, and five fire protection products, policies, or services (emergency medical memberships, fire sprinkler systems, fire alarms, fire insurance, and fire department medical calls) were not found to be cost beneficial. Expected value equations show that fire protection for the most part does not provide economic value, but the industry is protected by fire protection requirement laws. Cost effective analysis was used to determine cost per life saved for

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paramedic care, automated external defibrillators and helicopter emergency medical service, and smoke alarms. Paramedic care was found to be most cost effective followed by automated external defibrillators, helicopter emergency medical services and smoke alarms.

Cost Benefit Analysis Table

	Expected Benefit	Expected Annual Cost	Annual Return	Net Benefit Per Household
Fire Resistant Construction Materials	\$100.01	\$00.00	.0000	\$100.01
Volunteer Fire Departments	\$320.49	\$240.94	1.330	\$79.55
Fire Extinguisher	\$39.19	\$7.83	500.0	\$31.36
Emergency Medical Service Membership	\$31.32	\$48.00	.6525	-\$16.86
Fire Sprinkler System	\$15.33	\$150.00	.1022	-\$134.67
Fire Alarms	\$00.00	\$270.55	.0000	-\$270.55
Fire Insurance Policy	\$52.51	\$1,083	.0484	-\$1,030.49
Fire Department Medical Calls	\$00.00	\$1,478	.0000	-\$1,478.00

Smoke Alarms

The National Fire Protection Agency (2017) estimates the chance of surviving a reported home fire where working smoke alarms are present is 99.45 percent (100 - 0.55) vs. 98.87 percent (100 - 1.13) in home fires with no working smoke alarms. The first number is barely higher than the second. Each year, over 2,300 home fire deaths occur in more than 365,000 reported structure fires. The likelihood of surviving a home fire is approximately 0.0058 percent (0.9945 - 0.9887) higher for homes with a smoke alarm than one without. This suggests that smoke alarms save an estimated 13.34 lives per year (2,300 * 0.0058 percent). It would cost an estimated \$3.8 billion dollars to install \$30 smoke alarms, with a five year shelf life, in 127,590,000 United States households that could potentially save an additional 13 lives. Spending \$760 million (\$3.8 billion/5 years) to save 13 lives would cost \$58,461,538 per life saved.

Automated External Defibrillator

NIH (2018) estimated that each year more than 18,000 Americans have a shock able cardiac arrest outside of a hospital that occurs in public with witnesses. They further estimated that 1,700 lives are saved annually in the United States from bystander use of automated external defibrillators (AEDs) that cost around \$2,000. According to Zarilli (2015), nearly 100,000 automated external defibrillators were sold in 2010 so the total amount spent was roughly \$200,000,000 (\$2,000 * 100,000). Spending \$200 million annually to save 1,700 lives would come in at \$117,647 cost per life saved.

Helicopter Emergency Medical Service

Four reliable studies showed an overall reduction in mortality of 2.7 lives saved per 100 helicopter emergency medical service deployments (Ringburg, et al., 2018). The National Association of Insurance Commissioners (NAIC) reported that the average cost to transport a patient on an air ambulance is around \$18,750 (Araujo, 2019). The cost to transport 100 patients would total \$1,875,000, which would result in an overall reduction in mortality of 2.7 lives resulting in the cost per life saved to be \$694,444 (\$1,875,000/2.7).

Paramedic Care

The cost, including training, personnel, equipment, and response time maintenance, per year of life saved was found to be \$8,886.00 for paramedic care (Valenzuela et al., 1990).

Cost Effective Analysis Table

	Annual Cost	Lives Saved	Cost Per Life Saved
Paramedic Care	-	-	\$8,868
Automated External Defibrillator	\$200,000,000	1,700	\$117,647
Helicopter Emergency Medical Service	\$1,875,000	2.7	\$694,444
Smoke Alarms	\$760,000,000	13	\$58,461,538

Cost Per Lie Saved Determinants

Merrill (2017) reported that federal agencies value one’s life as much as \$10 million. Merrill (2017) also referenced Richard Thaler, winner of the 2017 Nobel Prize in Economics, who calculated the value of one’s life to be \$1.5 million in today’s dollars, and cited W. Kip Viscusi, professor of law and economics at Vanderbilt University, who applied a 37 percent lower life value for people 65 and older, which comes to around \$945,000 (\$1,500,000 * 0.63)

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per person. However, the amount state and local governments are able to pay is significantly less. On average, state and local governments collected \$1,144 per person from individual income taxes, but collections vary widely from state to state (Loughead, 2018). Governments would quickly go bankrupt spending significantly to save lives than the amount of taxes collected per taxpayer.

CONCLUSION

According to Zhuang et al., (2017), in 2014, fire protection services in the United States cost \$273.1 billion. The National Fire Protection agency (2017) reported that the 1,342,000 fires in the United States resulted in \$10.6 billion in property damage. The amount spent by United States fire departments was 25.7 (\$273.1 billion/ \$10.6 billion) times greater than the amount of home structural damage done by fires. City fire departments could potentially save money since the annual amount budgeted for fire protection services exceeds the total amount of structural fire damage by almost 26 times.

City fire departments save fire insurance companies money, but seldom provide value to homeowners who are required by law to purchase fire insurance for their house. Homeowners pay for fire protection twice with the purchase of fire insurance, and then with the payment of property and local sales taxes that cover the cost of fire protection services. If a city shuts down its career-fire fighter department and lets the insurance companies cover the costs caused by fire damage, the cost of fire insurance would increase due to increased fire risk, but the increase in premiums would be less money than the amount cities are charging the average household for fire protection services. More value could also be provided if: 1) cities shut down their career-fire fighter departments and simply required that all new houses be built with flame retardant materials; 2) cities shut down their career-fire fighter departments and just write checks covering the cost of the fire damage; or 3) cities shut down their career-fire fighter departments and create a construction department that repaired homes damaged by fire.

For many, these cost-cutting measures would provide up to 25.7 times more value than the current city fire protection services model which is not realistic. If cities are unwilling to consider these new ways of thinking, then they should at the very least consider new models on how to provide their communities with more value when it comes to fire protection services.

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