Understanding the Data Gap In Emergency Response: Evidence from U.S. 911 Agencies

Working Paper

About the Researcher:

Cirrus Foroughi graduated Harvard Business School with his Doctorate in Strategy in 2020. Trained as an economist, his work lies at the intersection of healthcare and technology, where he has a particular interest in how digitization affects productivity and outcomes, both for time-sensitive medical care as well as emergency response.

Prior to HBS, Cirrus was a research assistant at the National Bureau of Economic Research and the Federal Reserve Bank of Philadelphia, and is a graduate of Dartmouth College.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The COVID-19 pandemic has placed unprecedented stress on America's emergency infrastructure, with record 911 call volumes striking regions hardest hit by COVID-19.[1] This white paper looks to understand one of the largest sources of emergency calls in the United States — home and commercial alarms.

Americans spend over $60 billion annually on home and commercial security solutions.[2] These systems together generate an estimated 65 million emergency calls annually, representing approximately 27% of US emergency traffic.[3]

Using a combination of data analysis, live field testing, and interviews with 911 centers (hereafter referred to as Public Safety Answering Points, or PSAPs), this paper studies the interaction between alarm systems and first responders. 1.4 million emergency call records were analyzed from six major cities. We supported our public data findings with 283 field observations jointly collected with six PSAPs across the country. This data was augmented with a survey of 145 telecommunicators at PSAPs, as well as qualitative interviews from three PSAP directors. To maximize candor, PSAP director conversations were conducted on the condition of anonymity.

The results demonstrate a significant information gap between increasingly sophisticated alarm systems and the emergency services responding to their signals for help. Specifically, our testing and survey indicated that nearly all alarms are communicated via phone calls over the public switched telephone network (PSTN), limiting information flow to a verbal conversation between 911 telecommunicators and alarm monitoring center operators. The limitations of this legacy infrastructure often prevent 911 telecommunicators from acquiring enough information to triage and prioritize alarm calls.

Table 1: Average Alarm Response Time Summary (MM:SS)[4]

Time from Alarm Trigger to PSAP Call Mean (Median)	PSAP Process Time Mean (Median)	Dispatch to Arrival Mean (Median)	Cumulative Time[5] Mean (Median)
04:22 (04:00)	13:14 (06:22)	25:57 (15:17)	43:33 (25:39)

This lack of information leads to long PSAP processing time (6-13 minutes) and a proliferation of false alarms which clog first responder systems. Various studies have demonstrated that 90

[1] Watkins, Ali. "N.Y.C.'s 911 System Is Overwhelmed. 'I'm Terrified,' a Paramedic Says." *The New York Times*, The New York Times, 28 Mar. 2020, www.nytimes.com/2020/03/28/nyregion/nyc-coronavirus-ems.html.
[2] BARNES ASSOCIATES. "The 24th Annual BARNES-BUCHANAN CONFERENCE." *Security Alarm Industry Overview*, 2019.
[3] See Appendix A
[4] See Appendix C and D
[5] The cumulative response time was calculated by summing the discrete response time components: Time to PSAP Call, PSAP Process Time, Dispatch to Arrival

to 99% of all security alarms are false depending on the municipality.[6] We estimate the total yearly impact on the US emergency response system to be approximately 62 million false alarms at a cost of $3.1B annually.[7]

Unsurprisingly, the lack of information and tendency for false alarms causes most public safety agencies to deprioritize central station alarm calls. This challenge is magnified by the use of 10-digit non-emergency lines for incident reporting.

These factors converge to drive a high degree of variability in alarm response times and exacerbate the first responders' challenges in responding effectively to real alarm emergencies, given limited resources.

THE NEED FOR SECURITY & FIRE DETECTION

The home and commercial security industry focuses on responding to burglary and building fire.

According to the Department of Justice, a break-in occurs every 11 seconds in the United States.[8,9] Break-ins cause an annual $3.4 billion in property losses with the average property owner losing $2,799 per burglary.[10] The psychological impacts can be just as devastating: 65% of burglary victims never return to feeling fully safe in their homes and 10% even resort to moving into an entirely new home as a result of burglary.[11]

According to the National Fire Protection Association, a structural fire occurs every 23 seconds in the United States. Annually, these fires claim over 3,600 lives, cause over 15,200 injuries, and destroy $25.6 billion worth of property in the United States. The National Fire Protection Association reports that, "On average, there was a civilian fire death every 2 hours and 24 minutes and a civilian fire injury every 35 minutes in 2018." [12]

Given the impact on property and human life, it is not surprising that people value products that offer security and safety. A recent analysis by McKinsey & Co. found that 45% of American consumers are willing to pay more than $20 per month for health and safety monitoring services.[13] This demand is driving a $60B industry in the US.[14] As one industry insider notes,

---

[6] SCHAENMAN, PHIL, et al. "Opportunities for Police Cost Savings Without Sacrificing Service Quality: Reducing False Alarms ." *Urban Institute*, Nov. 2012.
[7] See Appendix A
[8] We are considering a break-in to be either a burglary or trespassing
[9] Morgan, Rachel E, and Barbara A Oudekerk. *Criminal Victimization, 2018*. U.S. Department of Justice, 2019, *Criminal Victimization, 2018*.
[10] Federal Bureau of Investigation. *2018 Crime in the United State - Burglary*. 12 Sept. 2019, ucr.fbi.gov/crime-in-the-u.s/2018/crime-in-the-u.s.-2018/topic-pages/burglary.
[11] Allianz Insurance. "BURGLARY HAS LONG LASTING EMOTIONAL IMPACT." *Mynewsdesk*, 17 Apr. 2015, www.mynewsdesk.com/uk/allianz-insurance/pressreleases/burglary-has-long-lasting-emotional-impact-1144858.
[12] Evarts, Ben. "FIRE LOSS IN THE UNITED STATES DURING 2018." *National Fire Protection Association*, Oct. 2019, www.nfpa.org/News-and-Research/Data-research-and-tools/US-Fire-Problem/Fire-loss-in-the-United-States
[13] McKinsey & Company. *THE CONNECTED HOME MARKET*. https://www.mckinsey.com/spcontent/connected_homes/pdf/mckinsey_connectedhome.pdf
[14] BARNES ASSOCIATES. "The 24th Annual BARNES-BUCHANAN CONFERENCE." *Security Alarm Industry Overview*, 2019.

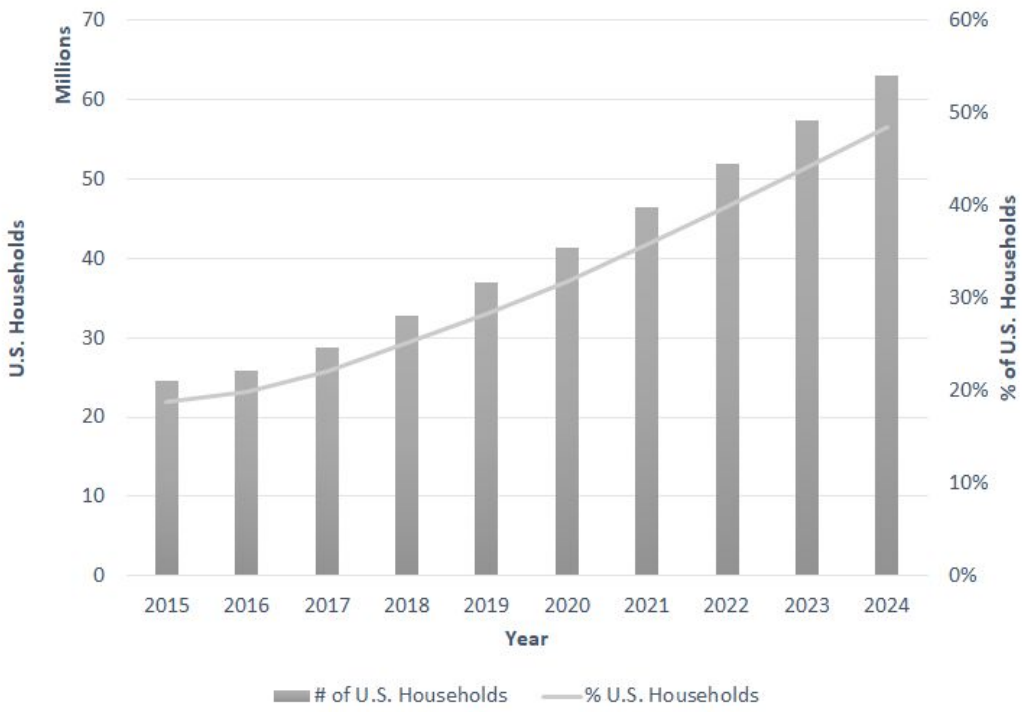
"Security continues to integrate more naturally into everyday lives — consumers see it as a necessity rather than a commodity...Security doesn't just turn on and off. Security is now a lifestyle. It's on all of the time".[15]

SECURITY SYSTEM ORIGINS

In 1853, Augustus Russell Pope patented the first modern burglar alarm. In 1858, the patent was sold to Edwin Holmes, who is credited with creating the modern security system. Under Holmes' leadership, the system evolved into the core foundation that can still be found in most modern systems, where buildings notify a central station staffed with human operators using the public switched telephone network (PSTN).[16] Since the 19th century, adoption of home and commercial security continues to grow from the niche communities in New York City and Boston Homes' onced served to cities all across the United States. Today, ADT alone serves over 6 million customers in over 200 American cities.[17] In 2019, 29% of American households owned a security system[18], paying an average of $40 per month for these systems.[19]

Figure 1: US Home Security Systems

[15] Hodgson, Karyn. "State of the Market: Security & Monitoring 2019." *SDM Magazine RSS*, SDM Magazine, 15 May 2019, www.sdmmag.com/articles/96283-state-of-the-market-security-monitoring-2019.
[16] Smith, Sean, et al. "Central Alarm Stations and Dispatch Operations." *The Professional Protection Officer: Practical Security Strategies and Emerging Trends*, Butterworth-Heinemann/Elsevier, 2010.
[17] "Our History." *History of ADT Security Company | Over 140 Years of Protection*, www.adt.com/about-adt/history.
[18] See Appendix A
[19] Imperial Capital. *Security Industry Monitor*. Dec. 2018, www.imperialcapital.com/publications/Industry/12052018840.pdf.



While modern security systems offer a variety of advanced sensor technology, the core process used to interface with first responders has not materially changed from the central station system developed in the late 19th Century. The process remains:

1. Detect emergency
2. Notify central station call center
3. Central station call center calls the PSAP
4. Emergency services respond to situation

Considering the US home and commercial security industry grew from just a few thousand homes in Boston and New York City in the 19th Century to 37 million homes nationwide in 2019, we set out to study the industry's impact on America's emergency response system.[20]

ALARMS & 911

The National Emergency Number Association (NENA) estimates that America's 6,000+ PSAPs receive 240 million emergency calls annually.[21] While little aggregated data is available about these 240 million emergencies, we examined public Computer-aided Dispatch (CAD) records from six major cities to better understand the impact of alarms on PSAPs.[22]

[20] See Appendix A
[21] NENA. "9-1-1 Statistics." *9-1-1 Statistics - National Emergency Number Association*, www.nena.org/page/911Statistics.
[22] See "CAD Records" in Appendix C

Given the varying taxonomies employed across the six datasets, a simple heuristic was developed to identify alarm calls based on whether or not certain keywords were present in a city's call classification scheme. As a result, our alarm dataset includes a broad range of alarm incidents (including security, fire, and panic in both home and commercial settings). Our dataset is also likely missing some subset of alarm calls whose classification name did not include any of our chosen keywords.[23]

Table 2 below summarizes the 1.4 million alarm calls identified and analyzed for this study.

Table 2: Public Data CAD Records

Agency	Population	Period	Alarm 911 Calls
City A	300,000	2015 - 2020	41,329
City B	675,000	2016 - 2020	71,139
City C	750,000	2009 - 2019	122,349
City D	400,000	2012 - 2019	342,225
City E	650,000	2012 - 2019	96,372
City F	8,400,000	2013 - 2019	780,336
Total	**11,175,000**	**2009 - 2020**	**1,453,750**

The fields appearing in the different CAD records were used to determine the following discrete response times: PSAP Process Time, Dispatch to Arrival Time, and PSAP to Arrival Time. The time between when a PSAP receives a call regarding a triggered alarm and the moment when the PSAP operator puts in a dispatch request for that call is referred to as the "PSAP Process Time." This includes the time it takes for the telecommunicator to receive a call, communicate with the central station, and manually enter relevant data about the alarm into CAD. The time between when the dispatch request was made and when emergency responders first arrive on scene is known as the "Dispatch to Arrival Time". The time between when a PSAP receives a call regarding a triggered alarm and when emergency responders first arrive on scene is known as the "PSAP to Arrival Time". Given that some CAD systems automatically assign values to the fields used to construct these times while other systems rely on manually entered information, the data was first cleaned in an attempt to remove any operational or system errors.[24]

The following table shows the average of all agencies analyzed.[25]

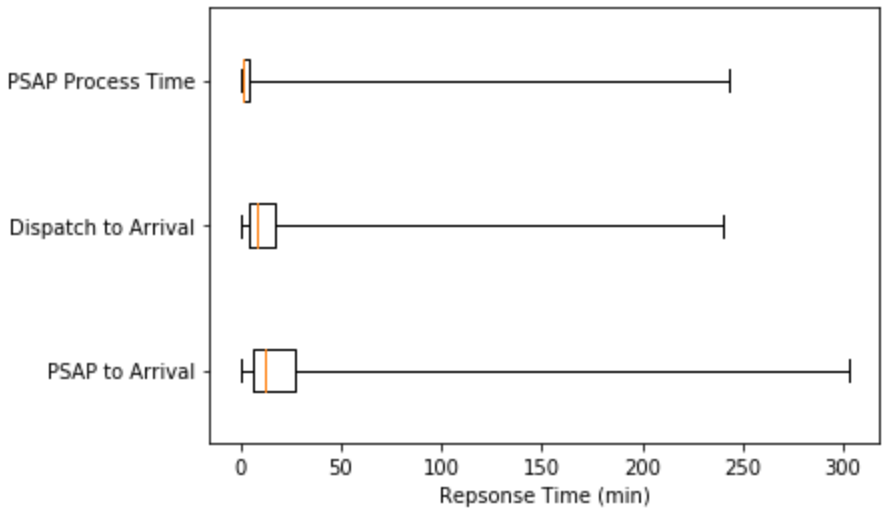
Table 3: Public Alarm Response Time (MM:SS)

[23] See "Identifying Alarm Calls" in Appendix C for more detail
[24] See "Calculating Response Times" in Appendix C for more detail
[25] See "Results" in Appendix C individual city response times

Agency	PSAP Process Time mean (median)	Dispatch to Arrival mean (median)	PSAP to Arrival mean (median)
Average	13:14 (06:22)	25:57 (15:17)	36:39 (20:42)

As Table 3 above shows, the average response time from when a PSAP is notified to an alarm emergency to when first responders arrive on scene is 36 min in our sample of 1.4 million incidents. This deviates significantly from the median of 20 min. This variation between median and mean is further highlighted by plotting against the full range of values as shown in Figure 2.

Figure 2: Public Alarm Response Time Distributions[26,27]



To understand the variability of response times and barriers to efficiency, as well as the parts of the alarm response unavailable in public records, our team conducted live testing and observations at several PSAPs throughout the country.

[26] Figure 2 does not include data from City F which does not provide response details on individual emergency calls
[27] Figure 2 shows a box and whisker plot. The edges of each line represent the minimum and maximum values for that particular dataset. The left edge of the box on a line represents that dataset's 1st quartile (25th percentile) The right edge of the box on the line represents that dataset's 3rd quartile (75th percentile). The line in the middle of the box represents the dataset's 2nd quartile (50th percentile), or median value.

UNDERSTANDING RESPONSE VARIABILITY: FIELD TESTING & PSAP INTERVIEWS

With the help of six PSAPs from Massachusetts, Illinois, Alabama, Mississippi and California, we observed the alarm response process for 283 live alarm calls, including eight from tests we conducted from systems we either purchased directly for the purpose of testing or were already installed in the homes of participating volunteers. In each case we observed and recorded how the alarm was received and processed by the PSAP. This field work helped shed light on what occurs in the time between when an alarm is triggered to when it is received by a PSAP, a component of the overall response time unavailable in public records. See Table 4 below to see the typical time of the initial response from when an alarm is triggered to when a PSAP was notified.[28]

Table 4: Field Data Alarm Response Time (MM:SS)

Agency	Time from Alarm Trigger to PSAP Call Mean (Median)
Average	04:22 (04:00)

We supported our field testing with an anonymous survey of 145 PSAP directors about their experience with alarms. In both our field tests and our surveys of 911 telecommunicators, we observed three types of challenges that impacted response times:

- Use of 10-digit non-emergency lines
- Insufficient information to assess/understand situation
- High false alarm rates

10 Digit (Non-Emergency) Lines

In our survey and field testing, all alarm calls came into the PSAP via a 10-digit non-emergency number (separate from 911). In each of our tests the call was immediately answered by the 911 agency, but we also observed that these calls are typically deprioritized compared to 911 calls.

While national 911 standards target answering 90% of calls within 10 seconds and 95% within 20 seconds,[29] no such standard exists for 10-digit non-emergency lines. Our discussions with PSAP directors indicate a wide degree of variability in how these 10-digit lines are managed. On a normal day there is likely limited to no impact on response times, but on a busy day or during a regional emergency event such as severe weather, the 10-digit line can be placed on hold.[30]

[28] See Appendix D for details

[29] National Emergency Number Association (NENA). "NENA Call Answering Standard/Model Recommendation." *NENA*, 2017, cdn.ymaws.com/www.nena.org/resource/resmgr/standards/NENA_56-005.1_Call_Answering.pdf.

[30] We note that some agencies capture this hold time in their CAD data but most do not, meaning that any delays from this step are likely not captured in our data analysis.

The use of 10-digit administrative lines also prevented even basic data from being available with a call — a 911 call typically carries contact and location information which is auto-populated in PSAP systems, but a 10-digit administrative line call does not carry that information. This created additional information challenges further described below.

> *"...They give us the alarm, and responders keep tripping alarms, then they keep calling. We tell them we have people on-scene and they keep calling that they are getting more trips of alarms. If after the first call, we tell them we are on scene, if they could stop calling in the alarm. The constant calling is problematic. If they would wait 10 minutes or a longer time, it would be okay, but they tie up lines and resources every trip of alarm."*
>
> *911 Telecommunicator from City H*

Insufficient Information to Assess/Understand Situation

A central station operator needs to assess incoming alarm information, attempt to contact and update homeowners, and then clearly articulate all of this information to a 911 telecommunicator.

Although most 911 telecommunicators in our field testing were able to clearly communicate with the central station operator, the central station operator rarely had any specific information on the incident. Generally the only information that was available was the address of the alarm and if the homeowner had been reached. In our survey we were told that even this information was sometimes inaccurate or outdated.

> *"...[Central Stations] not having the proper address or the proper jurisdiction... Their account information is not correct."*
>
> *"...Recently, some [Central Stations] don't have subscriber information. They don't have accurate addresses sometimes…"*
>
> *"...They [medical alarms] don't have much info when they call. Most do not have the age. They [Central Stations] don't get the info that we need in the PSAP…"*

We heard repeated stories of communication challenges that caused confusion, deprioritization,and delays in response, as well as a strong desire for more accurate, verified location information.

> *"It would be time saving ... pertinent information would not be missed if it was pre-loaded when the call comes in to a 911 center. Oftentimes, alarm companies provide a zone number for the location of the alarm, and then they do not know what that zone number indicates. Responding units do not know if it is from a front door, a window, or a motion detector."*
>
> *"Having all the verified information about the alarm displayed on screen as the alarm call comes in would be tremendously useful and time saving for the dispatcher."*

In a survey of 145 telecommunicators, 92% of respondents agreed that receiving verified information from a home security alarm directly on their screens would help dispatch the right

resources, faster.[31] 41% of respondents disagreed that information shared from alarm companies today is detailed enough to dispatch the right resources and provide necessary information to first responders.[32] Furthermore, 911 telecommunicators estimated that if alarm information were to display directly on their screens or they did not need to verbally verify alarm information, they would be able to save 3 to 5 minutes on average on dispatch time per emergency.[33]

High False Alarm Rate

The home security user base of 37 million American households are responsible for approximately 65 million alarm activations annually.[34] Of these alarm activations, an estimated 90% - 99% of all calls received by police are false alarms.[35]

False alarms are a material drain on public safety; researchers at Temple University estimate that if the false alarm problem was minimized, about 35,000 officers could be shifted to other duties.[36] As it exists today, false dispatches cost communities across the country an estimated $3.1 billion annually.[37]

Ultimately, the burden of millions of false alarms falls squarely upon PSAPs and the entire emergency response system. In our interviews with PSAP directors, we repeatedly heard frustration about false alarms. In Central Pennsylvania, one PSAP director said that they "made a separate non-emergency line for monitoring centers to call, so we could differentiate between citizen non-emergency calls and monitoring center calls. The monitoring center calls were an even lower priority than other calls."[38]

Absent data to distinguish between real and false alarms, it is not surprising to see public safety agencies treat most alarms as false.

CONCLUSION

America's home and commercial security industry fulfills a critical need of protecting families and businesses against theft, fire, and other life-safety threats. The industry has seen significant advancement in sensors and technology over the past 30 plus years. However, that technology has not yet penetrated the core back-end process of connecting to first responders in an emergency. When it comes to the most critical moment for an alarm system — getting first responders on scene promptly in an emergency — little has changed from the original process developed over 100 years ago.

---

[31] See Appendix B-1.
[32] See Appendix B-2.
[33] See Appendix B-3.
[34] See Appendix A
[35] SCHAENMAN, PHIL, et al. "Opportunities for Police Cost Savings Without Sacrificing Service Quality: Reducing False Alarms ." *Urban Institute*, Nov. 2012.
[36] Blackstone, Erwin A., and Simon Hakim. *Not Calling the Police (First)*. 2002, *Not Calling the Police (First)*, www.cato.org/sites/cato.org/files/serials/files/regulation/2002/4/v25n1-1.pdf.
[37] See Appendix A
[38] PSAP Director Interviews conducted by RapidSOS

The primary result is insufficient information available to PSAPs to allow them to safely, accurately, and effectively respond, creating a system that strains first responder resources by $3 billion annually and often leads to long response times with high variability. Technology has significantly impacted parts of the alarm industry over the past 30 years. A concerted effort to integrate that technology fully into the PSAP operational flow could significantly improve outcomes, ultimately saving lives and property.

APPENDIX A:
ALARM 911 CALL VOLUME, COST, & PENETRATION ESTIMATES

Total US Households with Security Systems	
2002 (Calculated)	
Total Households in 2002[39]	109,297,000
Percent of Households with Security Systems in 2002[40]	18%
(Calc) Households with Security Systems in 2002	19,673,460
2019 (From Source)	
Total US Households with Security Systems in 2019[41]	36,888,140
Households with Security Systems CAGR (2002 - 2019)	
Households with Security Systems in 2002	19,673,460
Total US Households with Security Systems in 2019	36,888,140
(Calc) Households with Security Systems CAGR (2002 - 2019)	3.8%

Alarm Activations Calculation	
Total Alarm Activations Responded by Police (2002)[42]	36,000,000

[39] US Census Bureau. "Historical Households Tables." *The United States Census Bureau*, 10 Oct. 2019, www.census.gov/data/tables/time-series/demo/families/households.html.
[40] Silverman, Fran. "DOMESTIC VIGILANCE ON THE INCREASE." *Courant.com*, 26 Sept. 2018, www.courant.com/news/connecticut/hc-xpm-2002-07-21-0207211190-story.html.
[41] Bustamante, Jaleesa. "IPropertyManagement Home Security Statistics ." *IPropertyManagement*, 28 Apr. 2020, ipropertymanagement.com/research/home-security-industry-statistics.
[42] Sampson, Rana. "Center for Problem-Oriented Policing." *False Burglar Alarms, 2nd Edition | ASU Center for Problem-Oriented Policing*, 2007, popcenter.asu.edu/content/false-burglar-alarms-2nd-edition-0#endref1.

Households with Security Systems CAGR (2002 - 2019) (From Appendix A)	3.8%
(Calc) Estimated Alarm Activations Responded by Police (2019)	65,050,305

False Alarm Activations

Estimated Alarm Activations Responded by Police (2019)	65,050,305
Estimated False Alarms as a % of Total Alarms[43,44]	95.0%
(Calc) Estimated False Alarms Annually	61,797,789

Cost of False Alarms

Estimated False Alarms Annually (From Appendix A)	61,797,789
Cost of False Alarms[45,46]	$50
(Calc) Estimated Total Annual False Alarms	$3,089,889,468

% of Households with Security Systems

Total Households in the US (2019)[47]	127,592,304
Households with Security Systems in the US (2019) (From Appendix A)	36,888,140
(Calc) % of Households in the US with Security Systems (2019)	28.9%

% of Alarm PSAP Calls

Total Annual PSAP Calls (2019) [48]	240,000,000
Estimated Annual Alarm Calls in 2019 (From Appendix A)	65,050,305
(Calc) % of Alarm PSAP Calls	27.1%

[43] The Urban Institute's study on false alarms concludes the false alarm rate ranged between 90 - 99%. For purposes of our calculations, we assume a false alarm rate of 95%.

[44] SCHAENMAN, PHIL, et al. "Opportunities for Police Cost Savings Without Sacrificing Service Quality: Reducing False Alarms ." *Urban Institute*, Nov. 2012.

[45] We derive an estimate of the average false alarm cost of $50 by using the Center for Problem-Oriented Policing estimate of 36 million false alarms in 2002 costing $1.8 billion

[46] Sampson, Rana. "Center for Problem-Oriented Policing." *False Burglar Alarms, 2nd Edition | ASU Center for Problem-Oriented Policing*, 2007, popcenter.asu.edu/content/false-burglar-alarms-2nd-edition-0#endref1.

[47] US Census Bureau. "Historical Households Tables." *The United States Census Bureau*, 10 Oct. 2019, www.census.gov/data/tables/time-series/demo/families/households.html.

[48] NENA. "9-1-1 Statistics." *9-1-1 Statistics - National Emergency Number Association*, www.nena.org/page/911Statistics.

APPENDIX B: SURVEY RESULTS

See below a summary of responses from a home security survey conducted with 145 telecommunicators at 911 centers:

Figure B-1: Survey Response to Statement: "Being able to receive verified information from a home security alarm (such as location, type of emergency, medical information, etc.) directly on my screen would help me dispatch the right resources, faster."

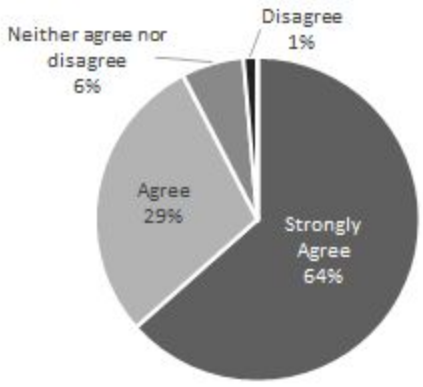


Figure B-2: Survey Response to Statement: Currently, I receive adequate information to dispatch resources and give first responders the information they need..”

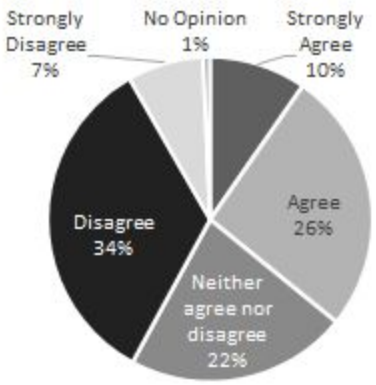
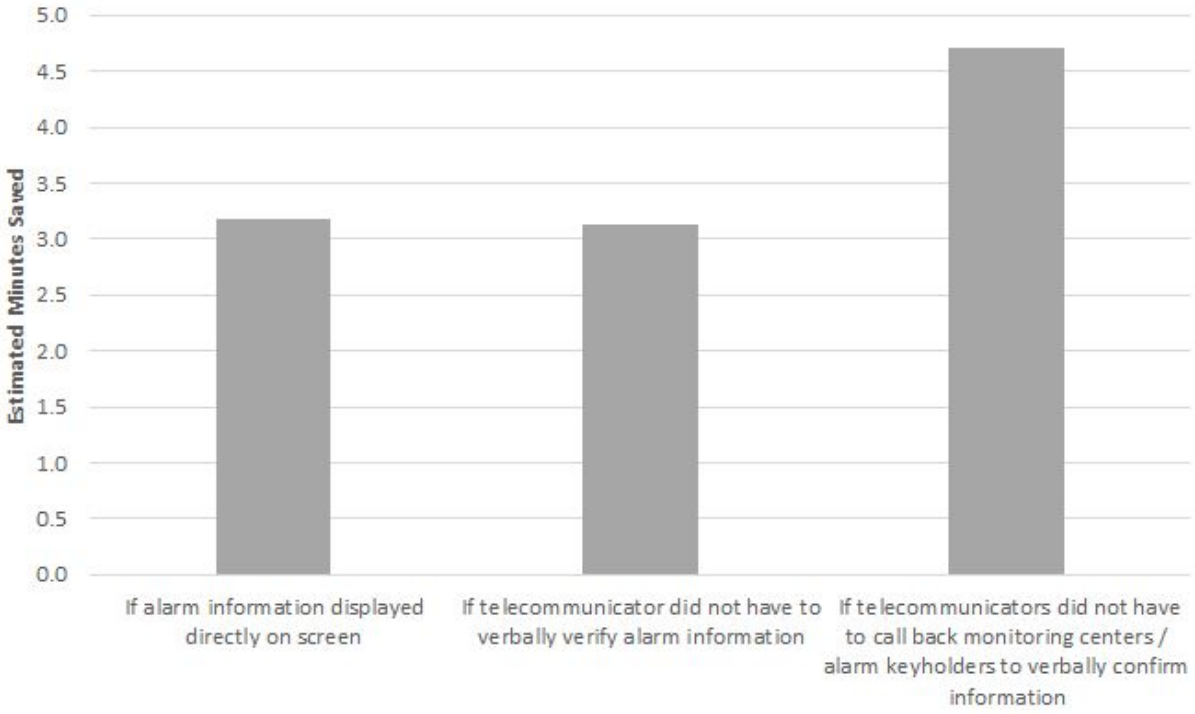


Figure B-3: Average Estimated Time Saved in Dispatch per Emergency (minutes)



APPENDIX C: PUBLIC DATA

CAD Records

Computer-aided Dispatch (CAD) software allows 911 telecommunicators to dispatch emergency services such as police, fire, and EMS. Note that the number of alarm CAD records is likely much less than the number of phone calls 911 telecommunicators field for alarms because not all alarm calls will result in a dispatch — often there are multiple calls for a single alarm event. Note that specific CAD incident data was available for all cities except City F which provided data already in an aggregate form.

Identifying Alarm Calls

Generic keywords were used to identify alarm incidents in public CAD records. This method was employed to handle the different methodologies used for classifying alarms across all the public CAD records. Although this approach likely excluded some incidents, it largely captured a broad range of alarm incidents, including security, fire, and panic alarms in both home and commercial settings. Our conversations with PSAPs directors supported this broad approach as an acceptable proxy for determining the response to a typical alarm 911 call. Our interviews with PSAPs specifically addressed the decision of whether to include panic alarms or not. Although panic alarms typically represent only a small fraction of all alarm calls, they are generally given a higher priority by the PSAP (similar to a regular 911 call) as a person normally has to physically activate the button indicating they are in immediate danger. Given the relatively low fraction of these calls, we determined it was unnecessary to attempt to manually remove these incidents, though their inclusion could skew overall results toward slightly shorter response times.

Calculating Response Times

Due to the different classification schemes employed in each city, each discrete alarm response time was constructed differently based on the fields available in the particular public record. As no keys defining an agency's classification scheme exist, best judgement was required interpreting the meaning behind each of the fields present. Consequently, we chose to only construct alarm response times when we had high conviction in our interpretation. Nevertheless, we acknowledge the discrete alarm response times calculated for each city do not align perfectly with each other due to differences in the fields available in each dataset, a lack of specificity on the definition of fields, and gaps in timestamps reported.

Calculating the PSAP Process Time in each city differed based on the data that was available. PSAP Process Time is conceptually the time between when a PSAP receives a call regarding a triggered alarm and the moment when the PSAP operator puts in a dispatch request. In practice, sometimes, the calculated time deviated from this ideal definition. For instance, in City D the PSAP Process Time was found as the elapsed time between the timestamp of dispatch and the timestamp of when the CAD record was created. As a typical telecommunicator workflow is to first receive an emergency call and then create a record in CAD, we expect that the PSAP Process Time calculated for this city to be shorter than reality. The impact of differences in the fields available in each also extends to calculated Dispatch to Arrival and PSAP to Arrival response times.

Discrepancies also exist between datasets due to a lack of specificity in field naming conventions. For example, some agencies fail to specify between the time when a dispatch request is sent and when

dispatch actually occurs. As there is often some gap between these two timestamps, the PSAP Process Time and Dispatch to Arrival response times calculated for each city might not be a perfect comparisons.

Additional discrepancies exist due to gaps in available data. For example, PSAP Process Time could not be reasonably constructed using the data available in City C and City E. In these cases, the PSAP to Arrival response time was conservatively approximated to be whatever shorter response time was available. Missing fields within individual alarm records also contributed to discrepancies. These missing fields within individual call records caused the sum of PSAP Process Time and Dispatch to Arrival PSAP to Arrival time to not always equal PSAP to Arrival time.

Despite these inevitable discrepancies, we stand that our attempt to aggregate these disparate datasets provides an accurate (albeit likely conservative) picture of alarm response times across the country. For full transparency, the table below provides each of the specific field names and the logic used to construct each response time in each city.

Table C-1: Public Alarm Response Time Calculation Methodology

Agency	PSAP Process Time	Dispatch to Arrival	PSAP to Arrival
City A	DISPATCH_TIME_PRIMARY_UNIT + CREATE_TIME_INCIDENT	ARRIVAL_TIME_PRIMARY_UNIT - DISPATCH_TIME_PRIMARY_UNIT	ARRIVAL_TIME_PRIMARY_UNIT - CREATE_TIME_INCIDENT
City B	intaketime	dispatchtime + traveltime	totalresponsetime
City C	#N/A	Arrived Time - Original Time Queued	Arrived Time - Original Time Queued
City D	TimeDispatch - TimeCreate	TimeArrive - TimeDispatch	TimeArrive - TimeCreate
City E	#N/A	TimeInQueue_sec + TravelTime_sec	TimeInQueue_sec + TravelTime_sec
City F	Call to First Pickup + Call to PD Calltaker Handoff + Call to Agency Dispatch	Call to Agency Arrival - Call to Agency Dispatch	Call to First Arrival (Multi-Agency Incidents)

Due to the high likelihood of operational and system errors in the CAD records, we attempted to “clean” our calculated response times of these errors by utilizing the following steps:

First we removed all negative response times as these negative values have no valid conceptual meaning and must be the result of some operational or system failure. After removing negative values, we removed the top 1% of all response times for each discrete response in every city. Removing the top 1% of values was a conservative measure taken to ensure we did not erroneously inflate our calculated response times by including high values caused by operational or system errors.

Results

Below are the results of our public data analysis broken out by response type and city. Averages were computed by creating an average of each agency's mean and median response type weighted by the number of alarm incidents.

Table C-2: Public Alarm Response Time by Agency (MM:SS)

Agency	PSAP Process Time Mean (Median)	Dispatch to Arrival Mean (Median)	PSAP to Arrival Mean (Median)
City A	04:34 (01:49)	06:24 (05:09)	11:20 (08:10)
City B	01:26 (01:18)	24:54 (11:47)	27:16 (14:12)
City C	#N/A	50:10 (21:41)	50:10 (21:41)
City D	13:49 (02:07)	06:51 (06:00)	21:36 (09:42)
City E	#N/A	21:29 (13:50)	21:29 (13:50)
City F	14:46 (08:40)	30:21 (19:49)	43:01 (26:39)
Average	**13:14 (06:22)**	**25:57 (15:17)**	**36:39 (20:42)**

APPENDIX D: FIELD DATA

Collecting Field Data

Our field data comes from observing and recording response times from live alarm calls. Data was collected through partnerships with six local PSAPs across the United States in two principal ways: conducting tests or recording timestamps of real life alarms.

All records from City G and City H are from tests conducted in conjunction with the local PSAP by intentionally triggering the alarm and manually recording the times the alarm was triggered and the time the PSAP received a call from the central station monitoring the alarm. All the other records come from real life alarms that were received by partnering PSAPs. The timestamp of when the alarm was triggered was provided by the central station calling on behalf of the alarm owner when asked by the 911 telecommunicator. Note that for agencies in City I, City J, City K this question was added to telecommunicators standard question protocol while this question already existed in City L. The fact that this information was already being collected as part of City L's standard question protocol and therefore could more easily be collected is the primary reason it makes up a bulk of our field records.

Calculating Response Times

In our field work, we were able to capture the "Time from Alarm Trigger to PSAP Call" alarm response time by recording times the alarm was triggered and the time the PSAP received a call from the central station monitoring the alarm.

Some discrepancies likely exist between response times calculated using our field data due to different potential answers to the question, "When was the alarm triggered?". For the typical security system, after an alarm is triggered there is usually some grace period of 30-60 seconds given to provide time for legitimate owners to disarm their systems. It is when this grace period is breached that the alarm will sound and the monitoring company will be notified. During our eight live tests we were able to timestamp the exact moment the alarm was triggered, however, it's less clear what timestamp central station operators provided 911 telecommunicators when asked the question "When was the alarm triggered?" The answer is conceivable as either the true trigger time or the time when the alarm sounded and when the central station was first notified. How the particular central station operator answered likely depends on the information available to them and their standard procedures, things that vary from one central station to another. Given the fact that we tested over 85 different security systems, it's likely there are some differences in how this question was answered. Bearing this in mind, our analysis should be viewed as a more conservative estimate of the typical response time.

Results

Table D-1: Field Data Collected

Agency	Population	Period	Observations	Different Security Systems
City G	120,000	Feb. 2020	4	4
City H	217,000	Mar. 2020	4	3
City I	49,500	Mar. 2020	19	11
City J	50,000	Mar. 2020	4	4
City K	415,000	Mar. 2020	7	4
City L	150,000	Dec. 2019	245	60
Total	**890,000**	**Dec. 2019 - Mar. 2020**	**283**	**86**

Table D-2: Field Data Response Time by Agency (MM:SS)

Agency	Time from Alarm Trigger to PSAP Call Mean (Median)
City G	03:40 (03:47)
City H	05:15 (04:34)
City I	04:35 (03:00)
City J	04:00 (03:29)

City K	04:09 (04:00)
City L	04:21 (04:00)
Average	**04:22 (04:00)**

ACKNOWLEDGEMENTS

I'd like to take a moment to thank the over 170 PSAPs that participated in this study, particularly those that helped facilitate live field testing and 'ride-alongs' where we classified and observed alarm calls. I'd also like to thank RapidSOS, an emergency technology company, who helped facilitate testing.

WORKS CITED

Allianz Insurance. “Burglary Has Long Lasting Emotional Impact.” *Mynewsdesk*, 17 Apr. 2015, www.mynewsdesk.com/uk/allianz-insurance/pressreleases/burglary-has-long-lasting-emotional-impact-1144858.

Barnes Associates. “The 24th Annual Barnes-Buchanan Conference.” *Security Alarm Industry Overview*, 2019.

Blackstone, Erwin A., and Simon Hakim. *Not Calling the Police (First)*. 2002, *Not Calling the Police (First)*, www.cato.org/sites/cato.org/files/serials/files/regulation/2002/4/v25n1-1.pdf.

Bustamante, Jaleesa. “IPropertyManagement Home Security Statistics .” *IPropertyManagement*, 28 Apr. 2020, ipropertymanagement.com/research/home-security-industry-statistics.

Evarts, Ben. “Fire Loss in the United States During 2018.” *National Fire Protection Association*, Oct. 2019, www.nfpa.org/News-and-Research/Data-research-and-tools/US-Fire-Problem/Fire-loss-in-the-United-States.

Federal Bureau of Investigation. *2018 Crime in the United State - Burglary*. 12 Sept. 2019, ucr.fbi.gov/crime-in-the-u.s/2018/crime-in-the-u.s.-2018/topic-pages/burglary.

Hodgson, Karyn. “State of the Market: Security & Monitoring 2019.” *SDM Magazine RSS*, SDM Magazine, 15 May 2019, www.sdmmag.com/articles/96283-state-of-the-market-security-monitoring-2019.

Imperial Capital. *Security Industry Monitor*. Dec. 2018, www.imperialcapital.com/publications/Industry/12052018840.pdf.

McKinsey & Company. *The Connected Home Market*. https://www.mckinsey.com/spcontent/connected_homes/pdf/mckinsey_connectedhome.pdf.

Morgan, Rachel E, and Barbara A Oudekerk. *Criminal Victimization, 2018*. U.S. Department of Justice, 2019, *Criminal Victimization, 2018*.

National Emergency Number Association (NENA). “NENA Call Answering Standard/Model Recommendation.” *NENA*, 2017, cdn.ymaws.com/www.nena.org/resource/resmgr/standards/NENA_56-005.1_Call_Answering.pdf.

NENA. “9-1-1 Statistics.” *9-1-1 Statistics - National Emergency Number Association*, www.nena.org/page/911Statistics.

"Our History." *History of ADT Security Company | Over 140 Years of Protection*, www.adt.com/about-adt/history.

Sampson, Rana. "Center for Problem-Oriented Policing." *False Burglar Alarms, 2nd Edition | ASU Center for Problem-Oriented Policing*, 2007, popcenter.asu.edu/content/false-burglar-alarms-2nd-edition-0#endref1.

Schaenman, Phil, et al. "Opportunities for Police Cost Savings Without Sacrificing Service Quality: Reducing False Alarms ." *Urban Institute*, Nov. 2012.

Silverman, Fran. "Domestic Vigilance on the Increase." *Courant.com*, 26 Sept. 2018, www.courant.com/news/connecticut/hc-xpm-2002-07-21-0207211190-story.html.

Smith, Sean, et al. "Central Alarm Stations and Dispatch Operations." *The Professional Protection Officer: Practical Security Strategies and Emerging Trends*, Butterworth-Heinemann/Elsevier, 2010.

US Census Bureau. "Historical Households Tables." *The United States Census Bureau*, 10 Oct. 2019, www.census.gov/data/tables/time-series/demo/families/households.html.

Watkins, Ali. "N.Y.C.'s 911 System Is Overwhelmed. 'I'm Terrified,' a Paramedic Says." *The New York Times*, The New York Times, 28 Mar. 2020, www.nytimes.com/2020/03/28/nyregion/nyc-coronavirus-ems.html.