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Reduced frequency and severity of residential fires following delivery of fire prevention education by on-duty fire fighters: Cluster randomized controlled study

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ABSTRACT

Introduction: In 2008, Surrey Fire Services, British Columbia, commenced a firefighter-delivered, door-to-door fire-prevention education and smoke alarm examination/installation initiative with the intention of reducing the frequency and severity of residential structure fires in the City of Surrey. *Method:* High-risk zones within the city were identified and 18,473 home visits were undertaken across seven temporal delivery cohorts (13.8% of non-apartment dwellings in the city). The frequency and severity of fires pre- and post- the home visit intervention was examined in comparison to randomized high-risk cluster controls. *Results:* Overall, the frequency of fires was found to have reduced in the city overall, however, the reduction in the intervention cohorts was significantly larger than for controls. Furthermore, when fires did occur within the intervention cohorts, smoke detectors were activated more frequently and the fires were confined to the object of origin more often post-home visits. No equivalent pattern was observed for the cluster control. *Impact on Industry:* On-duty fire fighters can reduce the frequency and severity of residential fires through targeted, door-to-door distribution of fire prevention education in high-risk areas.

1. Introduction

This paper details the methodology and impact of a fire fighter delivered, fire prevention public education campaign that successfully reduced the frequency and severity of residential structure fires within high-risk sections of the community in Surrey, British Columbia (BC). Relative to matched high-risk, cluster controls, this initiative was successful in two significant ways: first, through a reduction in the annual rate of residential house fires, and second, through an increase in the activation of smoke alarms and a reduction in the spread and associated damage of fires when they did occur. This paper concludes by discussing the lessons learned from this process and the intentions Surrey Fire Services have for expanding and developing these efforts into the future.

1.1. Motivation for Commencing a Public Fire Education Strategy

A review of best practices in residential fire safety from England, Scotland, Sweden, and Norway concluded, "Of all the best practices identified in this study, one stands out. To reduce fire casualties in the home, the British fire service is visiting large numbers of high-risk households to do fire safety inspections and risk reductions, especially to ensure they have a working smoke detector" (TriData, 2007, p. vi). In addition to this, recent trends have seen home visits becoming a crucial component of strategy designed to reduce residential fires in Canada (TriData, 2009). Examples of these types of initiatives have taken place in Longueil, Quebec, Ottawa, and Brampton, Ontario (TriData, 2009). These visits have targeted a range of issues, including the presence (and functionality) of smoke alarms, the development of fire escape plans, and information about the common causes of household fires. Overall, they have tended to focus on those sections of the community that pose the greatest risk for residential fire. Generally, the methodologies that have been used to complete the initiatives have tended to rely on either community-based volunteers (e.g., Schwatz, Grisso, Miles, Holmes, & Sutton, 1993) or have required additional funding (e.g., DiGuiseppi et al., 1999).

Critical review of these types of public education, targeted home visits have produced promising results examining a range of outcome measures, from reduction in rates of fires and fire-related casualty through to increased presence of working smoke alarms when residences were audited (e.g., Douglas, Mailonee, & Istre, 1998; Haddix, Mallonee, Waxweiler, & Douglas, 2001; Mallonee et al., 1996; McConnell, Dwyer, & Leeming, 1996; Schaenman, Stambaugh, Rossomando, Jennings, & Perroni, 1990). Overall, however, these strategies cannot conclusively be deemed to be effective (Warda & Ballesteros, 2007) given the general absence of appropriate randomized

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controls across studies, without which positive results must be interpreted with caution (DiGuiseppi & Higgins, 2000).

1.2. Aim and Hypotheses

Motivated by the generally positive findings of previous research into the impacts of public education campaigns on fire prevention, a firefighter-delivered, door-to-door fire-prevention education and smoke alarm examination/installation initiative was launched in the city of Surrey, BC, in 2008. The intention of this initiative was to reduce the frequency and severity of residential structure fires in the city. To ensure the impact of this initiative could be conclusively evaluated this research was designed with a randomized high-risk cluster control. Given the trends indicated in other areas it was hypothesized that this door-to-door information and smoke detector initiative would result in a reduction in the number of residential structure fires observed in the home-visit, intervention areas, and also that when fires did occur post-intervention, they should demonstrate qualitative differences reflective of the implementation of fire prevention information and possession of functioning smoke alarms.

2. Methodology

2.1. Selecting Dwellings for Distribution

As a precursor to developing a targeted public education campaign, the Surrey Fire Services commissioned the University of the Fraser Valley to undertake an analysis of fire incidence data to expose trends that had emerged over a 20-year period, from 1988 to 2007 (summarized in McCormick, 2009). One of the outcomes of this review was to identify some geographic areas that had displayed a relatively higher propensity for fire incidents between 2003 and 2007. This was done by creating a point-distribution map of the residential structure fires that occurred during this 5-year period, and then a series of ellipses were created to capture areas considered to have the densest concentration of fire incidents. These high-risk zones formed the basis of the broad catchment areas within which the public education intervention would be targeted. The approximate street areas encapsulated by these ellipses were then identified and the residential street addresses within these areas were sampled to generate the specific distribution targets. Sampling was structured to try and cluster sets of addresses geographically to minimize the amount of unnecessary driving that was being undertaken by the on-duty, career fire fighters who were making these visits. This approach represents a first attempt by the Surrey Fire Services at utilizing the non-random distribution of residential structure fires to guide a door-to-door public education fire prevention strategy.

A total of 18,473 dwellings within these high-risk zones were visited across seven temporal delivery cohorts (13.8% of non-apartment dwellings in the city), with deliveries within-cohorts undertaken across the response zones of the Surrey Fire Services' 17 fire halls. Prior to each distribution drive, each fire hall received a color-coded map which clearly indicated where the new addresses were that needed to be visited. Fire halls were also provided with a spreadsheet of addresses of homes to visit and a list of addresses that had been covered previously. Fire fighters were advised of the importance of ensuring they avoided visits to any of the addresses covered by previous waves of this initiative. These steps were taken to ensure that addresses within each of the identified high-risk ellipses were only visited once.

Despite these measures, it was possible that not all of the addresses extracted from the city planning records were the correct type of residential dwelling (e.g., non-apartments) for this initiative. In instances where fire fighters encountered unsuitable addresses they were instructed to make a judgment about completing the home visit in other suitable addresses that fell within the high-risk areas identified by the mapping exercise. In such cases, these addresses were subsequently recorded and the records updated retrospectively to maintain a current and complete list of dwellings that had been contacted by this campaign. Fire fighters continued this process until each fire hall had delivered their quota of information packages.

Fig. 1 displays the relative temporal distance of each cohort from the beginning and end point of this evaluation (with the solid dark lines indicating the post-intervention period associated with each cohort). As is clear from this diagram, there was a greater number of days pre-intervention, with Cohort 1 the only group with roughly equivalent number of days either side of the delivery of the public education, fire prevention information.

2.2. Distribution Methodology

Each cohort was reached over a one-week period, during which regularly scheduled training for fire fighters was suspended in order to allow time for the home visits to take place. Fire fighters were advised prior to each distribution effort that the overarching goal of this initiative was to visit homes in the city in a very direct and public attempt to prevent, and ultimately reduce, the number of home fires and fire injuries. Each allocated dwelling was visited once during this one-week period.

When a resident was at home, the fire fighters were instructed that each home visit was to take approximately 5 minutes at the front door. When contact with a resident was made, the fire fighters were to explain that residential house fires account for 75% of all fires in the city (McCormick, 2009) and to urge residents to review the fire safety material that was being delivered with all members of the household. Fire fighters also explained that the leading causes of home fires in the city were related to cooking and non-smoking related open flames (such as candles and matches, as indicated in McCormick, 2009). Residents were then asked about the smoke alarms in their household (was there at least one present, had it been tested recently, if not, could they please test it at the time, etc.). If the resident indicated that a functioning smoke alarm was not present, fire fighters were instructed to offer to install a free smoke alarm before completing their visit. Residents who accepted this offer were required to sign a waiver form and then the fire fighters installed the alarms at the time of the visit. All occupants were also informed that they could contact the Fire Prevention Branch of the Surrey Fire Services to arrange a complimentary follow-up home safety inspection. No comprehensive inspection was done at the time of the initial public education, smoke alarm inspection/ installation visit. In cases where no one was at home, the fire fighters were instructed to leave the package of information for residents to review upon their return.[1]

The fire-prevention information package provided a comprehensive, digestible coverage of a range of prevention-related topics, including:

- Smoke alarms: covering the purpose of smoke alarms, the types of smoke alarms available, where best to place smoke alarms, strategies to follow should a smoke alarm activate, smoke alarm maintenance;
- Home fire escape plans: discussing the realities of fire, the need and purpose of a home fire escape plan, how to behave should a fire start, particular individuals and locations that pose greater fire risks;
- Children and fire: outlining the curiosity that fire poses for most children, strategies for parents to reduce the likelihood of children setting fires (including education, removing temptation, teaching safe use of fire, and setting a good example);
- Senior fire safety: detailing strategies for seniors that maximize the likelihood of surviving a fire should one occur, the need to prepare and practice a home fire escape plan, strategies to reduce the likelihood of a fire occurring in the home (covering smoking behavior,

[1] It is unknown what the ratio was between homes that received personal contact and those that were only presented with the fire prevention literature. This distinction is being monitored and tracked as part of the distribution process post-evaluation.

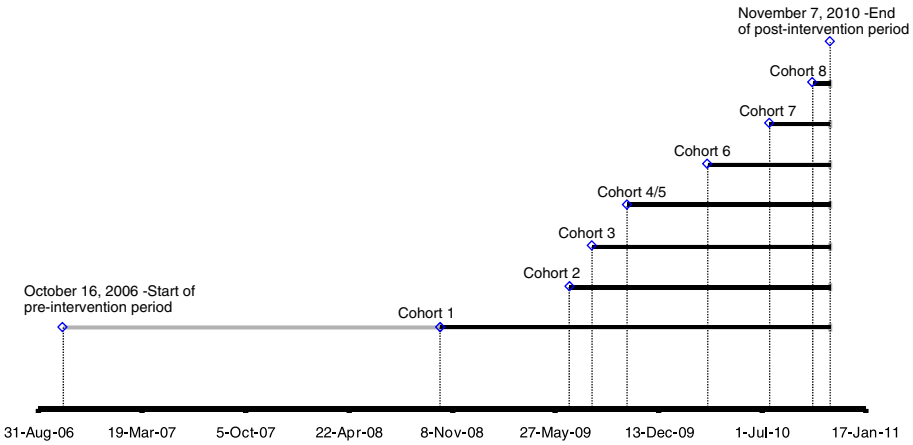

Fig. 1. Timeline of cohort distributions and the period of residential house fire data included in the evaluation (black-lines indicate post-intervention period for each intervention and high-risk control cohort).

use of heating equipment, and kitchen safety), and ways to behave safely should a fire occur; and

- Kitchen fire safety: explaining strategies for reducing the likelihood of a kitchen fire occurring (including cleanliness, use of cooking equipment, maintaining electrical cords, monitoring cooking, wearing short/tight-fitting sleeves, positioning pot handles inwards), ways to behave in the event of a kitchen fire, probable sources of ignition for kitchen fires (including grease, ovens, and microwaves), and appropriate ways to respond to burning clothing, burns to people, and children in the kitchen.
- A letter from the Surrey Fire Chief to the resident outlining the purpose of this initiative and emphasizing the availability of a no-charge home safety inspection and the offer to install free smoke alarms.

As this program was completed by on-duty career fire fighters, there was no additional expense involved with funding the delivery. Furthermore, the smoke detectors that were distributed in this case were donated to the fire service by the Surrey Fire Fighter's Charitable Association and the Guildford Mall, so there were also no additional expenses with respect to this aspect of the design. The only new money required to fund this exercise was for the production of the information packages, which worked out to cost approximately CAD1.40 per household.

2.3. Selecting a High-Risk Cluster Randomized Control Group

For evaluation purposes, it was essential to identify a randomized control group that possessed equivalent high-risk status within the community but had not received the fire prevention information and smoke alarm inspection/installation home visits. This process required an updated set of addresses to be identified, as the initially identified areas had all been visited at the time of the evaluation. The high-risk cluster controls were identified as follows. First, the specific addresses of all relevant types of residential fires[2] that had occurred in the city since late 2006 were mapped, and high-density areas were identified. In addition to this, Census information was used to identify areas of the city that would be expected to have an elevated likelihood of experiencing fires. This use of Census data built on research evidence that demonstrates an elevated risk of experiencing fire as a function of individual characteristics such as age (under 6 or over 64 years) (e.g., Jennings, 1996; LeBlanc et al., 2006; Scholer, Hickson, Mitchel, & Ray, 1998; U.S. Fire Administration, 1997, 2004), and socio-economic disadvantage (e.g., Jennings, 1999; Schaenman et al., 1990; Shaw, McCormick, Kustra, Ruddy, & Casey, 1988; U.S. Fire Administration, 1997, 2004). As a result, areas of interest were identified if they had a proportionally high representation of: (a) children aged under 6 years, (b) adults aged over 64 years, (c) single parent families, (e) high-residential mobility residents, and (f) unemployed residents. Census information about dwellings was also used to capture the variation in risk posed for residential structures as a consequence of fixed dwelling characteristics, such as building age (Jennings, 1996). This was achieved by identifying areas of the city with a large proportion of dwellings constructed pre-1991. The distributions of these risk indicators were then blended within ArcGIS and a new set of high-risk zones were identified across the city. The addresses within these zones were then sampled, and those previously visited within this campaign were removed, leaving a set of addresses that could be randomly sampled from to construct high-risk control cohorts that could be matched on cohort size (number of addresses) and pre-post intervention time periods.

3. Results

This analysis was approached from two perspectives. First, the frequency of fires experienced by the intervention and control cohorts pre- and post-home visits were compared. Second, the characteristics of the fires that were experienced by the intervention and control cohorts pre- and post-home visits were examined, to see if the intervention impacted on the severity of fires that did occur.

3.1. Rates of Fire Pre- and Post-Home Visits

As indicated in Fig. 1, previously, the data set for the first part of this analysis was extracted approximately 25 months after conducting the first cohort distribution. In order to compare the rate of fire pre- and post-intervention in each of the cohorts, the following process was completed. First, all relevant structure fire incidents were extracted from the Surrey Fire Service data system from the date two years prior to commencing the intervention. The set of relevant structure

[2] To be retained, fire incidents were required to meet one of three definitions: (a) residential and mobile home structure fires, for which an investigation was required; (b) electrical/stove/plug/dryer fires that occurred in a residential dwelling for which an investigation was required; or (c) an incident that occurred in a residential dwelling that required a post-fire inspection for which an investigation was required. These incidents were then screened to ensure the multiple approaches did not capture any duplicates. Subsequent analysis also revealed that this process had captured some vehicle fires (cars, trucks, or lawnmowers) and fires in garages, sheds, and outbuildings. All of these types of fires were also excluded.

fires were then searched to identify any incidents that had involved any of the addresses in either the intervention or high-risk control cohorts. Any incidents that had occurred were then classified as having occurred either pre- or post-intervention.[3] The rate of fires per 1,000 dwellings per year were then computed for each intervention and control cohort. These rates are displayed in Table 1.

A Home Visit (intervention vs. control) × Timing (pre- vs. post-) between-within ANOVA was conducted on these rates. Overall, there was a significant between-groups effect for Home Visit, $F(1,12) = 8.31$, $p < .02$. The effects for the within-groups analysis and the interaction were both non-significant ($F(1,12) = 3.83$ and 0.83, $p > .05$ in both cases). Post-hoc comparisons revealed no significant difference in the average rate of fire pre-Home Visit between the intervention and control conditions, $F(1,12) = 3.52$, $p > .05$. In contrast, the post-Home Visits comparison did produce a significant result, $F(1,12) = 6.56$, $p < .03$.

In percentage change terms, the difference observed in the intervention cohorts represented a 63.9% reduction in the rate of fires per 1,000 properties, per year, while the control group experienced a 14.6% reduction over the same period. With respect to the impact of this reduction on the observed frequency of structure fires in these areas, pre-intervention within the intervention cohorts, one residential structure fire occurred every 97.3 days. Post-intervention in the intervention cohorts the time period between fires increased by 95.7 days to one residential structure fire every 193.1 days. By comparison, in the control cohorts, the rate of fires was one every 64.1 days initially which increased to one every 67.8 days: a change of only 3.7 days per residential structure fire.

3.2. Severity of Fires Pre- and Post-Intervention

The intervention cohorts experienced 81 fires prior to the home visits occurring and 13 fires post-home visits. Over the same period of time the control cohorts experienced 123 fires and 37 fires respectively. For both intervention and control cohorts, Table 2 displays the relative percentages of these fires for which a smoke alarm was activated and the fire was confined to the object of origin. Table 2 also demonstrates the average fire loss (in Canadian dollars) incurred for these fires.

With respect to the fires that occurred in the intervention group, smoke alarms were activated more frequently following the home visits, $X^2(1, N = 94) = 5.57$, $p < .05$. In comparison, the control groups did not experience a significant increase in smoke alarm activation, $X^2(1, N = 160) = 1.18$, *ns*. A similar pattern was observed for fires that were confined to the object of origin, with a significant increase in the intervention condition following the home visits, $X^2(1, N = 94) = 6.61$, $p < .02$, but no change for the control cohorts, $X^2(1, N = 160) = 0.57$, *ns*. Finally, the pattern for total loss examined through a Home Visit (intervention vs. control) × Timing (pre- vs. post-) between-within ANOVA, producing a non-significant effect overall, $F(3,250) = 0.91$.

4. Discussion

4.1. Overview of Results

Overall, the pattern of results indicate that this fire-fighter delivered, door-to-door public education and smoke alarm examination/installation campaign was effective in reducing the frequency and the impact/severity of residential structure fires in the City of Surrey. Relative to the randomized cluster control cohorts, there was a larger decline in rates of fires per year per 1,000 dwellings in the intervention cohorts. In addition to this, when fires did occur, significant pre- and post-home visit differences were observed in the frequency of smoke alarm activation and confinement of the fire to the object of origin within the intervention cohorts, whereas no parallel findings were found for fires that occurred in the control cohorts.

Table 1
Average rate of fires per 1,000 dwellings per year across intervention and control cohorts.

Cohort	Addresses	Years pre-	Years post-	Avg. rate fires per 1,000 homes per year			
				Intervention		Control	
				Pre-	Post-	Pre-	Post-
1	2,747	2.00	2.07	2.18	1.23	3.64	3.34
2	2,716	2.68	1.38	1.23	0.00	2.61	1.33
3	2,690	2.80	1.27	1.19	0.59	2.65	1.47
4	2,627	2.99	1.08	0.76	0.71	2.04	2.12
5	2,803	3.41	0.65	1.05	1.09	1.99	0.00
6	2,407	3.74	0.33	0.56	0.00	1.00	1.27
7	2,483	3.97	0.10	3.04	0.00	2.03	4.08
Total	18,473	3.09	0.98	1.43	0.52	2.28	1.95

4.2. Methodological Limitations

At the time of evaluation it was unclear what proportion of the home visits involved a contact between a resident and a firefighter and what proportion only received the package of fire prevention information. This information is being collected for subsequent distribution cohorts. In addition, there would be benefit in conducting site visits at addresses that have experienced the home visits in the event that a fire occurs post-visit. This will also form part of the ongoing evaluation of this initiative.

4.3. Future Directions

Given the likely turnover of residents who reside within the city it is important to continue to monitor the impact and effectiveness of this campaign to ensure that the positive effects demonstrated so far for the dwellings that have been targeted with home visits are maintained. In addition to this, and in seeking to extend these positive results and continue to reduce the frequency and extent of residential structure fires, there are a number of strategies that can be explored. These can be grouped in two broad categories: intervention target selection and intervention delivery strategy.

4.3.1. Intervention Target Selection into the Future

The approach used to identify the control cohorts for this evaluation now drives target selection for future iterations of this home education campaign. In addition to this, there are also likely to be strong benefits from following the UK lead (e.g., Hampshire Fire and Rescue Service) and developing a forum to facilitate the sharing of information between service providers who work with high-risk members of the community and the fire service (Audit Commission, 2009). The range of local social service infrastructure involved in this

Table 2
Severity and response to fires pre- and post-visits for intervention and control groups.

Home visit condition	Timing	Number of fires	Alarm activated (%)	Confined to object of origin (%)	Avg. loss ($)
Control	Pre-visit	123	21.1%	16.3%	$41,341
	Post- visit	37	29.7%	21.6%	$56,242
Intervention	Pre-visit	81	17.2%	11.0%	$66,707
	Post-visit	13	46.2%	38.6%	$38,456

[3] The date displayed in Fig. 1 that marks the divide between the pre- and post-intervention periods was the end point of the week of visits undertaken within each cohort. This did not impact on the classification of any fire incidents (into pre- or post-home visit categories), with the shortest absolute time interval between this date and the fire incident of 31 days.

initiative included police, health bodies, voluntary organizations, community outreach teams, and local advocates, all working in partnership with the fire service to refer those at greatest risk of residential fire to have smoke detectors installed free of charge. The mapping process used to identify where to target prevention efforts could also be enhanced by building on the 'hot spot' identification recommendations that have been fine-tuned within a criminological context (e.g., Bowers, Johnson, & Pease, 2004; Eck, Chainey, Cameron, Leitner, & Wilson, 2005). Such a strategy would ensure the prevention efforts are continually focused on the highest-need areas of the community, with planning responding to the changing nature of the distribution of the problem across the city over time.

4.3.2. Intervention Delivery Strategy into the Future

The actual process and content of this public education campaign can also be developed with time and additional research. This could be approached in a number of ways. First, in developing the initial contact with members of the community it would be possible to adopt a similar attitude towards "selling safety" as has been the case in Merseyside, UK (Audit Commission, 2007). The range of strategies adopted by the Merseyside Fire and Rescue Authority include: (a) employing advocates who target interest from specific, high-risk sections of the community (such as the elderly, drug-users, new migrants, people with mental illness, etc.), and (b) telemarketing/cold-calling to generate customer base for the home inspections. In addition to this, the Merseyside Fire and Rescue Service provide a broader range of prevention tools than have currently been implemented in Surrey, including smoke alarms for deaf people, fire resistant bedding packs, and some sprinklers. Second, from an information delivery perspective it is possible to explore the potential benefits for utilizing contemporary, innovative approaches to communication, such as social networking media and modern capabilities for delivering messages (Murphy, 2010). It is likely that the greatest benefits of this approach would be achieved through partnership with external experts to ensure the prevention strategy was implemented in an effective manner. Third, in order to monitor the effectiveness of the campaign in a novel, ongoing way it would be plausible to explore the utility of developing a follow-up web-based questionnaire to see what impact this initiative has on cognition, awareness, and behavioral change. Topics covered could include: changes in behavior, changes in knowledge, retention of information, and anecdotes of success and these could all be documented and archived. This approach (surveys and focus groups) are currently utilized in Australia and New Zealand to evaluate fire prevention campaigns and to monitor public attitudes towards fire safety (TriData, 2008).

4.3.3. Impact on Industry

This successful initiative provides an example of the community safety benefits that are possible when city governments, fire department management, and crews of fire fighters are able to work in partnership and expand service levels into novel areas. The framework adopted here used a data-driven approach to target public education fire-prevention information to high-risk areas. The analysis approach utilized here enables ongoing monitoring of the impact this campaign is having in these areas of the city. Much as with problem-oriented approaches to policing, which have been demonstrated to have significant positive impacts on crime in many different instances, this system of partnership, dependence on data, and a focus on evaluation is one that has the potential to be implemented by all other fire departments and would be expected to produce equivalent, positive safety results wherever it is applied.

5. Conclusion

This study demonstrates strong evidence in support of the effective nature of home safety fire prevention visits. The comparison to cluster controls provides clear evidence of the benefits of these types of strategies. The benefits were demonstrated for both reduction in frequency and spread of fires, and also with respect to increased activation of smoke alarms. In addition to this, the methodology outlined here is a replicable process that can be administered by on-duty fire fighters as part of their daily duties. As Schaenman et al. conclude, in moving forward with the commitment to prevention, "The wide variety of materials used in the successful programs suggest that there are many ways to get the message across; the more important thing is to work on ways to find the right problem to tackle and the way to reach a significant part of the people who have the problem" (Schaenman et al., 1990, p. 114: 114). Consistent with the findings of the *Vision 20/20* (Vision 20/20, 2008) forum into national strategies for fire loss prevention, this ongoing commitment to prevention will continue to make a fundamental contribution to the goals of the Surrey Fire Services.

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