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New collaborations in daily emergency response

Applying cost-benefit analysis to new first response initiatives in the Swedish fire and rescue service

Introduction

The need to feel safe and to be able to access help quickly if an accident happens is something that concerns the citizens, who needs the help, as well as the emergency services¹, who provides the help. To be able to reach an incident scene quickly requires many resources to be located at accessible places in society. However, today local governments are struggling with budget constraints that limits the possibility to provide equal protection against accidents to all citizens. Other challenges, common for most emergency services throughout Europe, are an ageing population, lowered tax revenues in rural areas, long travel distances and more demanding clients. There are also indications of a higher workload within the emergency service organizations. In Sweden for instance the number of calls that require a response from the fire and rescue services (FRS) increased from approximately 110 000 to 125 000 per year from the year 2000 to 2013. At the same time the number of firefighters decreased from 17 650 to 15 620 (MSB, 2014). Hence the emergency services are struggling with making the response system more efficient in order to save lives, reduce damages, i.e. decrease societal costs (Wankhade and Murphy, 2012).

In Sweden it has been proposed that actors outside the traditional emergency services, e.g. security officers, home care nurses or chimney sweepers, can serve as additional resources or first responders to every day accidents in order to reduce response time and compensate for scarce resources (Pilemalm et al., 2014). Due to their availability in society, they might be able to contribute as first responders hence decrease response time and make a contribution before the traditional response organizations arrive to the incident scene. However, little research has been dedicated to investigating the possibilities and the potential benefits and costs from using this kind of non-traditional actors in daily emergency response²; existing studies mostly focus on early defibrillation (see e.g. Scholten et al., 2011 and Sund et al., 2012).

A common tool for evaluating policy initiatives in the public sector is cost-benefit analysis (CBA), where all the benefits and costs are monetized and compared to each other. Previous studies have highlighted the importance of evaluating the cost-efficiency of new first response initiatives (e.g. Jayraman et al., 2009; and Wallis, 2010 and Scholten et al., 2011). However,

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¹ In this paper we refer to the fire and rescue service, the police, the emergency medical services and the alarm centre.

² In most research first responders are only referred to as part of the professional emergency services² (e.g. Pelinka 1984 and Stenberg et al., 2010).

this is rarely done in practice and one explanation could be that it is difficult to capture and measure the actual effects.

In this study we will therefore apply CBA to new collaborations in the emergency services and show how to identify benefits and costs in a structured manner. We will also present numerical examples on how different effects can be valued monetarily. This can help decision makers handle some of the evaluation problems that most likely will occur. This study also contributes by identifying areas in need of more research and we also show that CBA can be used not only for measuring costs and benefits, but also for identifying potential improvements. *The purpose of this study is to analyse costs and benefits from new collaborations in daily emergency response and to demonstrate how cost-benefit analysis can be used for evaluating effects from these kinds of collaborations.*

The collaborations of interest in this study are between the FRS and new (non-traditional) actors. In the first case, security officers are used as first responders to FRS calls, and in the second, home care nurses assist the FRS at medical emergencies.

Examples of new collaborations in daily emergency response

There exist some studies where new collaborative practices have been evaluated from a cost-benefit perspective, at least when it comes to cardiac arrests or/and early defibrillation. In Sweden, UK, Australia and North America, firefighters can for example act as first responders and use automatic external defibrillators at medical emergencies (Lowton et al., 2010). Research has shown that the response time is reduced (Smith et al., 2001:a), and that the benefits in terms of saved lives, outweighs the extra costs for training and equipment (Sund et al., 2012). Furthermore, the firefighters appears to view their role as first responders as a positive addition to their emergency profession (Smith et al., 2001:b). An increased chance of patient survival after cardiac arrests has also been shown in cases where personnel such as casino security officers, flight attendants and taxi-drivers have received training and equipment in their workplaces (Valenzuela et al., 2000; Page et al., 2000 and Hollenberg et al., 2009). Another example is a project that was evaluated in the Netherlands, where SMS-alerts are sent out to volunteers in order to shorten the response time to cardiac arrests. Volunteers arrived before the emergency service personnel, started cardiopulmonary resuscitation and defibrillation and assisted them in several cases (Scholten et al., 2011). In Groeneveld and Owens (2005) it is found that it is more cost-efficient to train laypersons in CPR/defibrillation, who have a high possibility of encountering cardiac arrest incidents at work or at home, compared to training laypersons in general.

There exist a few studies that have been able to exemplify and demonstrate benefits for incidents other than cardiac arrests. However, none of these studies have tried to monetize the costs and benefits. In an evaluation of an experimental emergency first-responder system introduced in 36 small rural Georgia communities it was concluded that volunteers reduced the response time from 20 minutes to an average of 4.4 minutes (Kay and Myrick, 1982). In Sun and Wallis (2012), community leaders in Cape Town South Africa were trained to educate citizens in first response to a number of frequently occurring incidents. It was highlighted that

the first responders were using their skills for all sorts of emergencies; what effects these skills had on survivability or mitigation of damage was however not addressed. In Ali et al. (2006) a new public-private partnership between the police, the private sector and the community in Pakistan was studied, and a client survey demonstrated user satisfaction and an increased confidence in the services. However, also a number of problems were highlighted, including lack of proper equipment, guidelines and education.

While studies about training and implementation issues are valuable, we argue that it is important to also study the costs and benefits from these collaborations, not the least in a time where efficient use of public funds is vital.

Methodology

We use two cases to show how CBA can be used in different contexts. We selected newly started collaborations in order to gain good understanding of the initial start-up costs, and because this is a new phenomenon in Sweden, which makes access to data an important criterion. The two cases both includes the FRS as one part of the collaboration. However, the production of services differs institutionally; one being collaboration with a private firm (security officers) while the second case is collaboration between municipal bodies (home care nurses).

A number of different data sources have been used; interviews, public documents and incident reports. Thus, we have been able to cross-check data across multiple sources, which increases the robustness of the findings (George and Bennett, 2005). In total, 21 single interviews were conducted – where all respondents are key actors with strategic or operational positions – focusing on costs, benefits, conditions, resources, difficulties and potential for the collaboration.

Case 1. Security officers responding to fire and rescue service calls

Collaborations between the FRS and security officers have been studied in three Swedish municipalities; Söderköping, Södertälje and Botkyrka. Söderköping is a small municipality with roughly 15 000 inhabitants. They manage their own FRS, which is staffed by mostly part time firefighters with a call-out time³ of five minutes. Södertälje and Botkyrka, municipalities in the Stockholm region, have approximately 85 000 inhabitants respectively. They are staffed mainly by full time firefighters with a call-out time of 90 seconds. In all the three municipalities, security officers have historically been used for guarding and patrolling municipality buildings and infrastructure. The collaboration ensures that the security officers receive fire alarms at the same time as the FRS.

In Case 1 seven semi-structured interviews were conducted. Three interviews were held with security officers, two with security managers and another two with the FRS. For the municipality Söderköping, differences in response time as well as contribution from the security officers were studied through incident reports (the other municipalities lacked this data). 60

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³ The time from when the alarm reaches the fire station, until the fire engines leaves the station.

incident reports from the FRS and the security officers were compared in order to estimate the time savings and the contributions from the security officers.

Case 2. Home care nurses assisting the fire and rescue services while waiting for the ambulance

Case 2 was studied by reviewing a collaboration initiated in 2013 between the FRS and nurses in the municipal homecare in the municipality Öckerö in Sweden. Öckerö lies in the northern archipelago of Gothenburg and has 12,400 inhabitants. To visit Öckerö you have to go by boat or use the ferry transportation. Because of the demographic conditions, the response time can be long and ambulance resources are scarce. In 2002, the FRS at Öckerö began to assist the ambulance service in life-threatening incidents in order to reduce response times. However, since the FRS only has basic medical training the municipality decided in 2012 that nurses from the municipal homecare should complement the FRS with additional medical expertise. This cooperation was introduced during daytime in 2013.

Internal project documents and incident reports from the FRS were reviewed. Six semi-structured interviews with key-actors within the FRS, the home care and the ambulance services were held. Additionally, eight interviews were held with the nurses.

Applying cost-benefit analysis to evaluate new collaborations in emergency response

CBA gives a base for making decisions on whether a project is worth its cost when it is not possible or even desirable to perform market evaluations.⁴ A project is considered to be good if the change in social benefits exceeds the costs associated with the project. Benefits are defined in terms of willingness to pay (WTP) or willingness to accept (WTA) compensation. This is because social decisions should, as far as possible, reflect the interests, preferences and attitudes to risk of those who are likely to be affected by the decisions. In the case of safety, these interests, preferences and attitudes can be summarized by the amount that individuals would be willing to pay or require in compensation for small changes in the probability of death or injury during a forthcoming period (Layard and Glaister, 1994).

The change in welfare (W) from a project can be expressed as the sum of changes in consumer surplus (CS), producer surplus (PS), government budgets (B) and external effects (EE) over a time period (T) and discounted with an appropriate discount rate (δ^t) according to:

$$\Delta W = \sum_{t=0}^T \delta^t (\Delta CS_t + \Delta PS_t + \Delta B_t + \Delta EE_t)$$

Changes in government budgets (B) should be included since reductions in revenues means that governments have to spend less on something else or increase taxes, both of which reduce welfare. Most costs in the cases analysed in this paper will however fall on the producers and

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⁴ This happens when benefits and/or costs are not traded (or are priced wrong) at a market.

be captured by the producer surplus. We therefore assume that the effects of B are negligible.

Sometimes policy changes have impacts on stakeholders not paying for them (positive effects) or not being compensated for the effect (negative effects). These external effects (EE) should also be accounted for as benefits or costs since they affect the welfare of society. However, in this paper we assume that there are no external effects since all individuals in society can be considered consumers. By studying consumer and producer surplus (CS and PS) we will thus be able to capture most effects. Therefore, these are more thoroughly explained and discussed from an emergency service perspective in the following sections.

Measuring consumer surplus in emergency services

Consumer surplus (CS) is defined as the difference between the value the consumers of a good or service puts on consuming it and the price they actually pay for it (see e.g. Boardman et al., 2011). This can be seen as an approximation of the utility, and in practice when evaluating policies it is the change in CS that is of interest. From the perspective of the consumer, collaborating with new actors might reduce the response time. This might lead to a higher degree of survival and reduced damages or a higher perceived level of safety. However, measuring these benefits is not an easy task; potential life savings, reductions in property damage and increased safety have a value but are not traded at a market, hence do not have an explicit price.

When using CBA, we are interested in individuals' WTP for these changes. However, estimating WTP is both resource and time consuming. Attempts has been presented in Mattson and Juås (1997) where the importance of the time factor was estimated for the FRS. This was done by measuring the benefits and costs for society if the FRS arrives earlier or is delayed by 5 and 10 minutes respectively. This has been further developed in Jaldell (2004) and applied in Sund (2006). The time values do however assume that a full rescue team arrives to the incident scene hence the time values needs to be adapted to the capabilities of the new first responders if they are to be evaluated. Some examples of time-values per minute for different incident types are presented in Table 1.

Incident type	Value per minute in 2011 prices
Fire in building	~ \$4400
Fire not in building	~ \$160
Traffic accident	~ \$2740
Drowning accident	~ \$8400
Medical related alarm	~ \$1000

Table 1. Examples of time values from Jaldell (2004) in 2011 prices using the exchange rate SEK/USD =7

There has also been extensive research on the value of a statistical life (VSL) which can be used to monetize changes in mortality risk (see e.g. Viscusi and Aldy, 2003). To estimate VSL, economists study the behaviour of people or ask them about their WTP for reduced risk. Then for a given change in risk (Δr), VSL is calculated as WTP divided by (Δr). This value can be used when evaluating the effects from saving a life in an accident (see e.g. Sund, 2012). In

Sweden the VSL from the transport department is commonly used, and this is estimated to \$3.2 million. This can be compared to the U.S. Department of Transportation, who uses \$9.2 million (U.S. DT, 2014). VSL is a concept that has been widely debated and many claim that it is not possible to put a price on life. Also the different kinds of values that exist among countries can make it seem as if some lives are worth more than others. However, the VSL varies a lot due to differences in income, risk perception or even the methods used when asking people about their WTP. The VSL should therefore mostly be seen as a statistical value that can help policy makers when making decisions about safety enhancing activities.

It is also likely that a non-user value exists in the demand for emergency services. Just as for insurances, many individuals are probably willing to pay for emergency services, even though they might never need to use them. Also, even if a security officer or a nurse is not able to intervene in a specific case, their presence may create a sense of safety that represents a value to the residents. Calculating only the user-value will therefore underestimate the total benefit if this is not taken in consideration.

When there are no market prices, it is possible to use other methods to estimate individuals' WTP. One method is the contingent-valuation method (see e.g. Boardman et al., 2011). This method entails asking direct questions to individuals on their (hypothetical) maximum WTP for a policy that increases the individuals' utility. In Sund (1998), it was estimated that the WTP for FRS in selected municipalities in Sweden was approximately 600 Swedish crowns (~ \$84) per household and year (in 1998 prices). A similar study was presented in Asgary and Mehdi Moeni (2012) where the WTP for enhancing local emergency preparedness was studied. In that study households from 59 communities in Canada were asked about their WTP and that study showed that households were willing to pay \$52.43 to enhance emergency management programmes. Even without going into details regarding what the households were willing to pay for, it is evident that there exist a positive WTP for enhanced emergency services.

Measuring producer surplus in emergency services

Producer surplus is the difference between what the producer gets paid for a good or service and the variable cost of producing it (see e.g. Boardman et al., 2011). In the cases analysed here, the FRS, the security officers and the nurses can all be considered to be producers. What needs to be valued are the increased resource usage, e.g. in terms of time and material that are needed for the collaborations and the operations. There are several factors increasing the costs, e.g. education, material and communication. Evaluating the opportunity costs⁵ for material and communication is quite straightforward since these are goods or services that have an actual price on a functioning market that can be used as an approximation.

When it comes to education of the security officers or nurses this can be estimated by the production lost when a firefighter educates a security officer or a nurse. This in its turn can be valued by multiplying the time spent on education with the hourly salaries, since salaries can

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⁵ Opportunity costs measure the value of what society must forgo to implement the collaboration, e.g. work that might have been done by the security officers if not responding to FRS alarms.

be seen as the value the employer puts on the services produced. The same applies for turn-out costs. Since the nurses and the security officers now have to respond to alarms, there will be occasions when they have to leave their ordinary duties. The costs for this can also be estimated by using the time spent responding to an alarm multiplied with the value of that time, which can be estimated with salaries.

Findings

When conducting a CBA of a specific policy there are certain steps to follow that simplifies and structures the analysis. These are described below, together with findings from the interviews and the document studies from the cases.

Define the objective of the project and define relevant alternatives

The main objective, in the two cases studied here, is to increase the level of safety and security in the municipalities by providing additional resources that among other things can contribute to a decrease of the response time in case of accidents or urgent out-of-hospital medical need. For Case 1, the objective was not only to reduce response times and assist the FRS, but also to prevent vandalism in the municipalities. In Case 2, the main objective is to increase the level of medical expertise when the FRS responds to medical alarms. Another goal was to reduce the response times.⁶

Identify costs and benefits from the project

From the interviews and the document studies it emerges that one of the most important benefits in Case 1 is that the security officers quickly can reach the incident site, thereby breaking or mitigating the accident development at an early stage. The security officers also have good local knowledge and keys to many buildings, and can be helpful by providing information or assisting the FRS. This may shorten the time from alarm until it is possible for the FRS to start the rescue work. It has also been discovered that the preventive work the security officers perform by talking with young people and other groups in society have a positive effect which is important in a long-term perspective. The costs for the collaboration consist mainly of the extra material that is required; medical kits, extinguishing materials such as fire extinguishers and fire blankets, as well as communication equipment. Costs also arise when the FRS educate the security officers, and when security guards respond to emergencies (turn-out costs). The costs and benefits are summarized in Table 2.

For Case 2, it is not possible to identify any benefits based on historical data, since the actual number of responses that the nurses had made was only three at the time of the study. In these three cases, they arrived after the FRS and/or the ambulance, and did not take an active part in the rescue work. One explanation for the low number of responses (data shows that they had

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⁶ It is important to consider that all projects or changes have alternative courses of action, one of them being the null-alternative, i.e. to do nothing. Of course it is possible to pursue the same objectives in other ways, but there is no indication that any alternatives have been discussed and dismissed in the two cases. Therefore, we compare only to the null-alternative.

the possibility to respond to 17 incidents during the investigated time period) can be the fact that many of the nurses were reluctant to accept this new responsibility and felt insecure and unprepared (which might be regarded as a cost for the project). Another reason is the lack of clarity in the routines. The nurses emphasize in the interviews that they are not completely sure about which incidents they should respond to, which creates uncertainty that delays the mission. The long response times also seem to be due to late dispatch by the alarm centre and a routine stating that the nurse is supposed to call the FRS before leaving to agree on a meeting place.

Benefits	Costs
Reduced response times	Extinguishing material (investment and replenishment)
Situational awareness	Training and education (Initial and continuous)
Keys and good local knowledge	Medical kits
Preventive work	Radio sets/beepers
Additional tasks during the response work	Turn-out cost for security officers

Table 2. Selected benefits and costs for Case 1 identified in the interviews

Looking instead at the expected benefits when launching the project, the nurses can provide more advanced medical care than the FRS, e.g. administer drugs. They are also more experienced in meeting and treating patients, which might be regarded as a benefit if this leads to an improved experience for the patients. Furthermore, the FRS has expressed that they would benefit from additional medical competence when treating children, since they feel unsure about how to handle those cases. Thus, the nurses can improve the work environment for the FRS, even if the medical benefits turn out to be small.

Benefits	Costs
Higher medical competence	Material (investment and replenishment)
Better patient experience	Training and education (initial and continuous)
Improved work environment for the FRS	Continuous medical care costs
(Potential time savings)	Lowered service level for ordinary patients
	Worsened work environment for nurses

Table 3. Selected benefits and costs for Case 2 identified in the interviews

In contrast to the benefits, some of the costs in Case 2 are fairly easy to estimate, e.g. costs for material (clothes, a mobile phone, a car, etc.) and education. Other are more uncertain, such as how the cost for the continuous treatment of the patients will be affected by the nurses' response, e.g., if the nurse saves a life that otherwise would be lost, there is a benefit for the saved life, but at the same time a cost for the continuous medical treatment that otherwise would not exist. However, if the nurses' response improves the condition for a patient that would have survived anyway, the medical treatment cost will probably be lowered compared to the null-alternative. Other uncertain costs are the possible opportunity cost for a lowered service level for the nurses' regular patients, and a cost for the perceived worsened work environment for

the nurses that are adverse towards the project. However, improvements of the routines for when the nurses should go to the incident site as well as faster alarming could also add a time effect to the benefits. The costs and benefits are summarized in Table 3.

Quantify costs and benefits in monetary terms

Once the benefits and cost have been identified, they have to be quantified (measured). As discussed previously, finding monetary values for the benefits is far from easy. However, it is not necessary to quantify all benefits and costs to be able to perform a useful quantitative analysis. It is important though, to keep in mind what has been left out.

For Case 1, the work that is performed by the security officers before the FRS has reached the site can be quantified into monetary terms. Using time values from Jaldell (2004) it is possible to find a number for how much value that can be saved if the security officers can reach an accident Δt time units earlier than the FRS. However, the security officers cannot be assumed to be capable of handling all types of emergencies by themselves. Let us call the proportion of the total effort conducted by security officers for p . This depends on the emergency type and at which the stage the security officers arrive. If they arrive at an early stage when e.g. a fire is not fully developed, it is likely that the security officers can manage to put out the fire, i.e. $p = 1$. But if they arrive when the fire has spread, the security officers will not have the same possibility to mitigate the fire by themselves, that is, p will likely be less than one. Therefore it is important to evaluate the proportion of the effort that has been handled by the security officer. The time value for the incident is v . The total benefits from the interventions are called B :

$$B = \sum_{i=1}^n B_i = \sum_{i=1}^n (\Delta t_i \times p_i \times v_i)$$

where n = number of incidents.

We investigated incidents for the municipality of Söderköping more carefully, since data from the other municipalities was lacking. Together with the fire chief, seven incidents, out of 60 ($n=60$), were identified where the security officers arrived before the FRS and were able to mitigate or extinguish a fire, i.e. $p > 0$. The fire chief estimated that the proportion of the total effort handled by the security officers in the seven identified cases was 100 percent. In five of these cases, they suppressed small fires with no risk for diffusion or large social cost. However, two of the suppressed fires implied substantial risks for spreading and damage. By calculating the time saved in the two latter cases, the proportion of the effort being handled by the security officers and the value of that time, it is possible to conclude that the saved value from these efforts amounts to approximately \$61 600⁷. Dividing this value by the time the collaboration had been ongoing (2.5 years) gives an average yearly benefit of \$24 600.

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⁷ All prices are expressed in 2011 years prices using Swedish consumer price index. The value of 1 minute faster response is \$4400, the security officers reached the fires 11 respectively 3 minutes earlier than the FRS and performs 100% of the work: 11 minutes $\times$ 1 $\times$ \$4400 + 3 minutes $\times$ 1 $\times$ \$4400 = \$61 600.

In general, the costs in Case 1 are quite straightforward to evaluate at least for material and refill. The costs are presented in Table 4, where some are initial investment costs and others annual costs.

Cost element	Costs
Material	~ \$1370 (investment)
Education	~ \$2500 (investment)
Turn-out costs	~ \$960 (annual costs)
Operational costs	~ \$900 (annual costs)
TOTAL COSTS year 1	~ \$5700

Table 4. Investment costs and annual costs for Case 1

Costs exist for material (investment of \$1370) and education (investment of \$2500). The cost for education is represented by the opportunity costs for the FRS and the security officers expressed as their wage costs during the time spent on education. This is seen as an investment since there are no plans for further education. The turn-out costs for the security officers is calculated by using the average time spent at the incident scene (on average 0.5 hours) multiplied with their wage costs for that time which amounts to \$960 per year. The refill of fire extinguishers is estimated to a total of \$900 per year.

Case 2 offers even more of a challenge than Case 1 when trying to quantify the benefits. Although the literature is ambiguous, there exist some evidence as well as expert opinions, claiming that receiving earlier medication for certain symptoms is beneficial (see e.g. Red Cross, 2011). Examples include the administration of oxygen for drowning victims or scuba divers with decompression illness, as well as the use of auto-injectors in case of severe allergic reactions. While not easy, it should be possible to investigate how much more valuable it is in terms of mortality and reduced suffering if a nurse reaches the patient early, compared to if e.g. the FRS reaches the patient first. Given that such a study can provide times values such as the ones used in Case 1, it is also possible to quantify the value of the nurses' responses. For the data we have in Case 2 however, the value would be zero, since the nurses did not reach the patients quickly enough.

Investments in material	Costs
Clothes	~ \$19 000 (investment)
Car	~ \$6850 (annual cost)
Communication support	~ \$1200 (investment)
Medical equipment	~ \$3500 (investment)
Education	~ \$26 500 (annual cost)
TOTAL COSTS year 1	~ \$57 050

Table 5. Investment costs and annual costs for Case 2

To assign a value to the possibly enhanced patient experience, studies are needed to show how much more patients value being taken care of by a nurse instead of a firefighter. In contrast,

existing studies points out the value of human contact no matter the level of medical competence (Elmqvist et al., 2008). Likewise, the value of improved work environment for the FRS is very difficult to quantify.

Like in Case 1, the costs for material and education in Case 2 can be described in monetary terms. The investments and the annual costs are presented in Table 5. The hours spent on education as well as the number of participants is summarized in Table 6.

Education	Time spent [h]	Nr of nurses	Nr of trainers
CPR/Emergency care	16	20	2 ambulance personnel
Practice in the ambulance service	16	20	2 ambulance personnel
Medical education	4	20	1 physician

Table 6. Amount of education for Case 2

By using data on average wages from Statistics Sweden for the different occupations taking part in the education we can conclude that the cost for education amounts to ~ \$26 500⁸. At the time of the study, the nurses had not been given any further training. However it was highlighted that there will be a need for exercises and updates, so therefore we assume that these are annual costs.

Since no quantified benefits can be calculated for Case 2, we will instead show how it is possible to analyse which benefits that must be reached for the project to reach a break-even when discussing sensitivity analysis.

What becomes clear from looking at the quantified costs is that much more resources have been spent in Case 2 compared to Case 1. The nurses have been given more education and more material (clothes being a high cost item for instance).

Discount benefits and costs to obtain present value

The different costs and benefits identified and calculated will occur at different periods of time during the lifespan of the project. In order to make the costs and benefits comparable, they have to be converted into measures at a single point of time (usually today). Future costs and benefits should therefore be discounted with a suitable discount factor (in Sweden this is set to 3.5 percent) reflecting individuals preferences for consumption today to consumption in the future.

Since the investments made in the two cases have different time spans, we convert costs and benefits (that are not already expressed as annual) to annual costs and benefits using annuities. In order to do this we needed to determine the economic timespan of the investments as well as which costs that will appear annually (operational costs). This was done by asking the managers about the investments and how long the material can be used (e.g. a defibrillator has a time span of 4 years, clothes 10 years, cell phones 3 years etc.). Investment costs are then converted into

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⁸ Costs for education = $W_s \times t_s \times X_s + W_u \times t_u \times X_u$

where:

W_s = Hourly wage nurse, t_s = nr of hours, X_s = nr of nurses participating.

W_u = Hourly wage trainers, t_u = nr of hours, X_u = nr of trainers.

annuities by multiplying it by an annuity factor:

$$a_r^n = \frac{1 - (1 + r)^{-n}}{r}.$$

where n is the number of years and r is the discount rate. The annuity factor for clothes is e.g. $(1 - (1 + 0.035)^{-10}) / 0.035 = 8.32$. The annual cost for the investment is then obtained by dividing the net present value (NPV) of the investment – which in our case is the investment cost in the beginning of the project – with the annuity factor. The annual cost for clothes in Case 2 for example, is thus calculated as $\$19\,000 / 8.32 = \$2280$.

The total annual cost for Case 1 during this time has been calculated to approximately $\$3000^9$. The annual benefit is approximately $\$24\,500$. The cost-benefit analysis suggests that the benefits from time savings amount to 8 times the invested amount.

In Case 2, total annual costs are calculated in the same manner. The interviewees provided us with cost data and helped us estimate the life span of different equipment. The total annual cost is calculated to $\sim \$48\,620^{10}$. The results are summarized in Table 7.

	Yearly benefits	Yearly costs	Benefits/Costs
Case 1	\$24 500	\$3000	8
Case 2	-	\$48 620	-

Table 7. CBA results for Case 1 and Case 2

Perform sensitivity analysis

For Case 1, the CBA suggests that the benefits amount to 8 times the invested amount. However, the analysis is based on a limited data set, and the monetized value of the benefits is based on only two specific events. Therefore, it is important to analyse the robustness of the results.

For the collaboration to be continuously profitable, the security officers must perform time-saving interventions that exceeds the costs of $\sim \$3000$ a year. Using the time values from Table 1, and assuming that the security officers can perform valuable work at the incident site, this can be achieved in a number of ways, e.g.:

- They arrive one minute before the FRS at one incident per year, at a fire in a building.
- They arrive 30 seconds before the FRS at one incident per year, at a drowning accident.
- They arrive five minutes before the FRS at four incidents per year, at fires not in buildings.

⁹ The sum of annuities of the investment costs in Table 4 ($\$1370$ and $\$2500$) using a discount rate of 3,5% and different time spans for the investments, plus the annual costs $\$960 + \$900$. The market prices are then corrected with an additional cost of 30%, the marginal cost of public funds used to reflect the tax on the productive alternative use of private consumption and the cost for public funds (ASEK, 2012).

¹⁰ From Table 5, the sum of annual costs is $(\$6850 + \$1200 + \$3500 + \$26\,500 = \$33\,350)$. The sum of annuities of the investment costs in Table 5 using a discount rate of 3,5% and different time spans for different investment is approximately $\$4000$. The sum of discounted investment costs and annual costs are multiplied with the marginal cost of public funds (30%) so that: $1.3 \times (\$33\,350 + \$4000) = \$48\,620$.

Looking at the historical data, the security officers arrived before the FRS at 34 out of 60 occasions. The mean time saving was 4 minutes, and in 31 of the 34 occasions, they arrived more than one minute before the FRS. Thus, it is clear that the security officers most likely will be able to perform activities that outweighs the costs – even when just considering the reductions in response time. Since the costs are low and there are benefits that are not possible to value, this collaboration will probably be continuously cost-efficient.

For Case 2, the total annual costs amount to ~ \$48 620 and no benefits could be quantified. However, by calculating what the nurses have to achieve for the collaboration to be profitable it is at least possible to make a judgment on whether the cost is reasonable or not.

If it is possible to change the routine so that the nurses are able to reduce the response time, it is also possible to use the time values from Table 1 like in Case 1. Medical related incidents have a time value of \$1000 per minute, which means that in order to cover the costs, the nurses would have to arrive, e.g.:

- five minutes before the regular emergency services at ten occasions per year, or
- one minute before the regular emergency services at 50 occasions per year.

The number of medical related cases per year that the nurses can be dispatched to varies between 150 and 200, which means that both the examples above are realistic. However, changes in the collaboration setup is needed to enable a quicker response.

Another visualizing example is if it would be possible to conclude that the nurses saved a life, that otherwise would have been lost:

- Valuing a life to \$3 200 000, this would cover the cost for the collaboration for 66 years.

It is also important to consider that the cost evaluation contains uncertainties and lacks some cost items. For instance, we have not taken into consideration the perceived decrease in utility for the nurses from having to perform these new tasks and we have not been able to consider costs for administration and management since this was not documented anywhere.

Considering that the nurses at the time of the study had responded to only three incidents, it is difficult to argue that the benefits exceeds the costs. However, the evaluation was made at an early stage and several potential improvements have been identified. Therefore, it is still possible that the collaboration might be cost-efficient at a later stage.

Discussion

In Figure 1, the most important identified effects are grouped as changes in consumer and producer surplus.

	Case 1 (security officers)	Case 2 (home care)
Consumer surplus	+ Reduced response times + Assistance to FRS + Preventive work (- Primary task)	(+ Reduced response times) + Assistance to FRS + Patient benefits - Primary task
Producer surplus	- Material - Education - Turn-out costs + Satisfying work	- Material - Education - Turn-out costs - Dissatisfying work

Figure 1. Summary of consumer and producer surplus components for the two cases

Contributing to the consumer surplus, are the effects that the consumers would be willing to pay for. The most obvious effect is reduction in response time, which makes it possible for the consumers to get quicker help. The consumers might also have a willingness to pay for the assistance that the new actors can give to the FRS, e.g. by increasing the situational awareness for the FRS before they arrive, or by assisting the FRS at the incident site. The preventive work that the new actors contribute with (Case 1) as well as the higher level of medical knowledge at the incident scene (Case 2) are also benefits that the consumers might perceive as valuable. However, most of these benefits are difficult to value monetarily. The only actual benefit that we have been able to value in this study is the reduced response time from having more resources responding to alarms.

What might be regarded as a cost for the consumers – and thus a reduction of the consumer surplus – is the potentially decreased quality in the primary tasks performed by the nurses or the security officers. In Case 1 these are probably quite low since their primary tasks consist of building inspections and other patrolling duties which can be resumed as soon as an incident has been taken care of. However in Case 2 this might induce a substantial cost for the collaboration if the nurses have to leave patients in the home care for helping patients that needs acute care. This is a potential decrease in consumer surplus (a cost) that should be considered when designing the collaboration. However, apart from the possible cost from not being able to receive the benefits from the primary task, the collaborations will only lead to benefits for the consumers.

The consumer surplus should however not be surpassed by the decrease in producer surplus. Most costs fall on the producers, and are easier to estimate monetarily than the benefits. They represent the increased resource usage e.g. in terms of time and material that are needed for the collaborations and the operations. An interesting difference between the cases is that in Case 1 the security officers experience the new tasks as an increase in utility that improves their professional role whereas the nurses in Case 2 experiences this as a decrease in utility. More research on how different types of new actors adapt to these new initiatives could therefore contribute to the literature.

The analysis performed in this paper indicate that the case with the security officers (Case 1) most likely was socially beneficial, while the case with the home care nurses (Case 2) at the

time of the study was not. However, as evident from the analysis of the two cases, it is difficult to acquire stable quantitative results when applying CBA on emergency response initiatives, especially when targeting new structures and initiatives. What must be kept in mind is that much of the difficulties in valuating effects will also occur using other evaluation methods. By using CBA it is possible to, at least, identify the costs and thereby estimate what is needed in terms of benefits for the net present value to be positive.

CBA provides a structured and thorough method for studying and evaluating these kinds of initiatives. Benefits and costs uncovered during the process also have a value in themselves, as they can be used as starting points for improving the projects. E.g., in Case 2 it is evident from the analysis that more benefits can be reached if the alarm process is improved to reduce the time before the nurse starts travelling towards the patient. In the analysis, a number of problems preventing this are also discovered (e.g. the nurses as well as the FRS gets the alarm later than the ambulance), and suggestions for how these can be removed (send the alarm simultaneously to ambulance, FRS and the nurses, and improve the routine for when the nurses should go to the incident scene) can be given.

It is possible to discern two important areas where further work is needed for it to be possible to fully utilize CBA for quantitatively evaluating new projects within FRSs:

1. Project documentation and data collection
2. Further research on quantifying effects

The first area concerns the lack of data evident in the two cases studied here. In the case of the security officers, the collaboration had been ongoing for some time and multiple responses had been made. Still for the larger municipalities, documentation was lacking stating when the security officers had arrived and what kind of work they had performed. The same data is of course necessary for Case 2, along with information about the work after the actual response, and how the primary assignment (in Case 2, taking care of the regular patients) is affected by the new tasks. In general, by introducing a suitable documentation standard it should be possible to capture many of the costs the project gives rise to, e.g. material, education, training, administration as well as the cost for performing the response.

Even if it was possible to obtain all the desired data and information from the projects, some costs and in particular benefits would still be elusive. Today, we lack the proper understanding to fully be able to quantify the effects of the different tasks that are performed during an emergency response. It is for example not possible to say with any certainty, how the first response by a new resource, will affect the course of an accident. Indeed, even with traditional resources, no really good models exists that can be used to predict the consequences from an accident given that we send a specific set of resources. Here, more research is needed. Furthermore, most of the benefits identified in this study, cannot be expressed in monetary terms, and need to be investigated further before it is possible to include them in the quantitative analysis.

Conclusions

The purpose of this study was to analyse costs and benefits from new collaborations in daily emergency response and to demonstrate how cost-benefit analysis can be used for evaluating effects from these kinds of collaborations.

Based on the two case studies, it is possible to conclude that new actors can be cost-efficient when utilized in emergency response. While it is necessary to provide proper routines, equipment and training, it is perhaps even more important to ensure that the new responsibility is accepted and embraced by the new actors. One way to achieve this could be to include the proposed new responders at an early stage when developing the collaboration, to capture concerns and ideas that they may have.

Cost-benefit analysis is useful as a method when studying these types of collaborations. Benefits and costs are revealed, and can be qualitatively valued even if they cannot be quantified. Areas for improvement are also identified as a bonus. Still, as the ultimate goal of the analysis is to be able to determine the cost-efficiency of the collaboration, better documentation and additional data logging is required, especially concerning the responses made by the new actors. This data can then be used to create better models for how to evaluate and quantify the benefits and costs generated by the new actors, which would give an excellent base for evaluating similar initiatives even before they are launched.

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