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Less Pain More Gain!

Lucas Hawkes-Frost argues the case for improving Pain Management in ambulance and looks at future options in pain assessment and management

Also Inside:
John Barker provides a Paramedic's guide to the HCPC process

Calling on Support Networks is the Key to Improving OHCA

Below Tef Jansma, a Dutch Post-graduate student of Industrial Engineering and Management reports on the academic study he recently undertook with UMCG Ambulancezorg and the University of Groningen as part of his M.Sc. His study explored new models of improving OHCA (Out-of-Hospital Cardiac Arrest) in the Drenthe region in the North of the Netherlands; perhaps unsurprisingly, Tef's research results have indicated that the most cost-effective way of increasing OHCA survival rates is to reach out and form partnerships with other Emergency Services providers and community volunteers.

1. INTRODUCTION

Emergency Medical Services **(EMS)** are an essential link in patient pathways. EMS performance is typically measured through a response time performance, in which there is no distinction between patient groups. The EMS network has been set up in an attempt to meet these legally defined norms. Consequently, patient groups that require medical care much quicker than the norm on responsiveness prescribes may face the consequences of this policy: a lower effectiveness of their treatment. One typical patient group is the group of patients who are having an out-of-hospital cardiac arrest **(OHCA)**. An OHCA is cessation of cardiac mechanical activity that is confirmed by the absence of signs of circulation and that occurs outside of a hospital setting. In a recent project, the EMS provider for the region of Drenthe (*see Figure 1*), located in The Netherlands, researched opportunities for improving the survival rate for OHCA patients by extending their current network with third party networks.

Figure 1: the region of Drenthe in the Netherlands.

2. CHAIN OF SURVIVAL

Effective treatment of an OHCA can be done using the 'Chain of Survival' concept, which suggests a time-phased treatment, including cardiopulmonary resuscitation **(CPR)**, defibrillation and advanced care[1]. CPR entails chest compressions, and optionally breaths. CPR is meant to preserve blood circulation, so that the residual oxygen in the blood remains transported through the body. Defibrillation is the act of providing an electrical shock to the victim. This is usually the only way to cause the heart to start beating again. Advanced care consists of care services such as intubation, setting up an infusion and providing the victim with medicines.

Figure 2 shows that the effectiveness of OHCA treatment is strongly time-related[2,3,4]: the survival rate depends on the elapsed time since the collapse, and whether CPR is provided. The solid line, which represents the survival fate of a patient without CPR treatment, declines very quickly. In this case, any intervention after eleven minutes is futile. The dashed line represents a situation in which the patient receives CPR, starting 2 minutes after the collapse. This intervention causes the survival rate of the patient to deplete more slowly.

Biography: Tef Jansma

Tef Jansma was born in 1987 in Kampen, The Netherlands. After finishing gymnasium he initially studied at the University of Delft, and then later moved to the University of Groningen to study Industrial Engineering and Management. As part of his research he chose to connect with external companies.

During his bachelor's degree at AVEBE he optimized the internal pallet streams to reduce waste and costs and then during his Master's degree he executed a simulation study at NORMA, a supplier of Philips, to design an optimal system for product scheduling and routing.

Tef has held a number of teaching assistant positions in logistics and simulations. It was his passion for healthcare which led to his decision to execute his Master's research at UMCG Ambulancezorg, which in turn resulted in the Master's research project on OHCA featured above.

Outside of work and study Tef has a broad range of interests, including sport, salsa dancing, traveling, motorcycling, and website and graphic design.

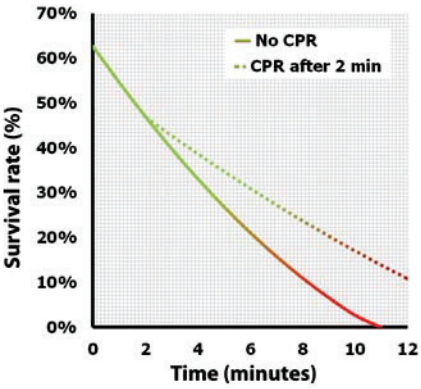

Figure 2: survival rate (%) as a function of time (min) with no CPR given (solid) and CPR after 2 minutes (dashed).

3. CURRENT EMS NETWORK PERFORMANCE

Current survival probabilities for OHCAs in the region of Drenthe are 10% - 15%. This number contrasts with findings in literature, which suggests that a survival rate of 25% is attainable[5,6]. A likely explanation for these low scores is that the current Dutch EMS network setup is tailored towards a sufficient 15-minutes response time performance for high priority calls. Clearly, such norms hinder effective treatment when following the Chain of Survival concept, which requires interventions to be done much sooner. Analysis of the current network using dedicated simulation tools[7] relying on geographic information systems **(GIS)**, showed that only 6% of the calls concerning OHCAs are served within four minutes, while 51% of the calls are served within eight minutes. Figure 3 shows how this impacts on treatment effectiveness. Zones that are marked red identify parts of the region that cannot be served in time for effective OHCA treatment, implying low survival rates.

4. EXTENDING THE CURRENT NETWORK

The first step an EMS provider must take to improve EMS responsiveness is to adapt its own ambulance network. Response times can be improved by changes in the number and location of posts and vehicles, one-type or mixed vehicle fleet, staffing, dispatching procedures, and relocation strategies. A first analysis showed that the proximity of posts near calls is especially relevant for achieving short response times, whereas other parameters are of less importance. Given that only 4% of the blue light responses are OHCAs, the number of vehicles and staffing is less of an issue in optimizing network performance.

Crude analytical approximations show that full coverage of calls concerning OHCAs can be achieved by adding 169 posts to the current network. The estimated additional annual costs of this network extension are €118 million. Clearly, such additional costs cannot be covered by a regional EMS budget. Furthermore, this addition would yield very low post-utilization rates. This, in turn, would imply major professional quality issues: how could quality levels be maintained when the call volumes per post drop so steeply?

More refined simulation experiments show that the survival rate itself also hardly benefits from the addition of more posts. For example, three additional posts in poorly-covered areas only increase the survival rate by 1.0%: from 11.5% to 12.5%. Interestingly, the addition of just one post right in the centre of a call hotspot, the city of Assen, has more impact: the survival rate increases by 1.4%. This confirms the above insight that proximity of care-givers is relevant in EMS network design. Note that survival probabilities have been estimated by linking timeliness of treatment to its effectiveness[8].

5. ALTERNATIVE NETWORKS

Since adapting the current EMS network turned out to be unfeasible, other networks have been explored. Alternative networks can be combined with the current EMS network to improve responsiveness.

Three guidelines have been used to search for solutions. Firstly, the care-givers need to be in close proximity to the patient. Secondly, the care skills must be sufficient for the care provided. Thirdly, an automatic external defibrillator **(AED)** must be available.

Three alternative networks have been considered: those of the firefighters, police and volunteers. After a first screening, it was decided to not explore the police network in detail, as their network is not significantly denser than that of the EMS itself. All alternative solutions have been tested for survival rates and its costs assessed through GIS simulations.

5.1 Firefighters

The firefighter network in Drenthe has two interesting properties: it is almost three times as dense as the EMS network, and it is largely operated by volunteers, who are much less expensive than EMS staff. Also, here in the Netherlands, firefighters can provide CPR and defibrillate. Hence, the firefighter network seems to offer great potential.

Simulation experiments indicate that a hybrid EMS + firefighter network allows for large improvements. The amount of patients that could be served within 8 minutes increases from 51% to 74%, while the survival rate increases to 17.6%. The improvements are visualized in Figure 4. It clearly shows how the coverage of the extended network improves, as compared to the current network (*see Figure 2*). Also, this network extension is very cost-effective, as it comes at an additional yearly cost of only €50.000. The costs mainly come from equipping the firefighter's cars with AEDs, so that they are readily available. The gain in survival rates is primarily explained by the fact that more patients receive timely defibrillation.

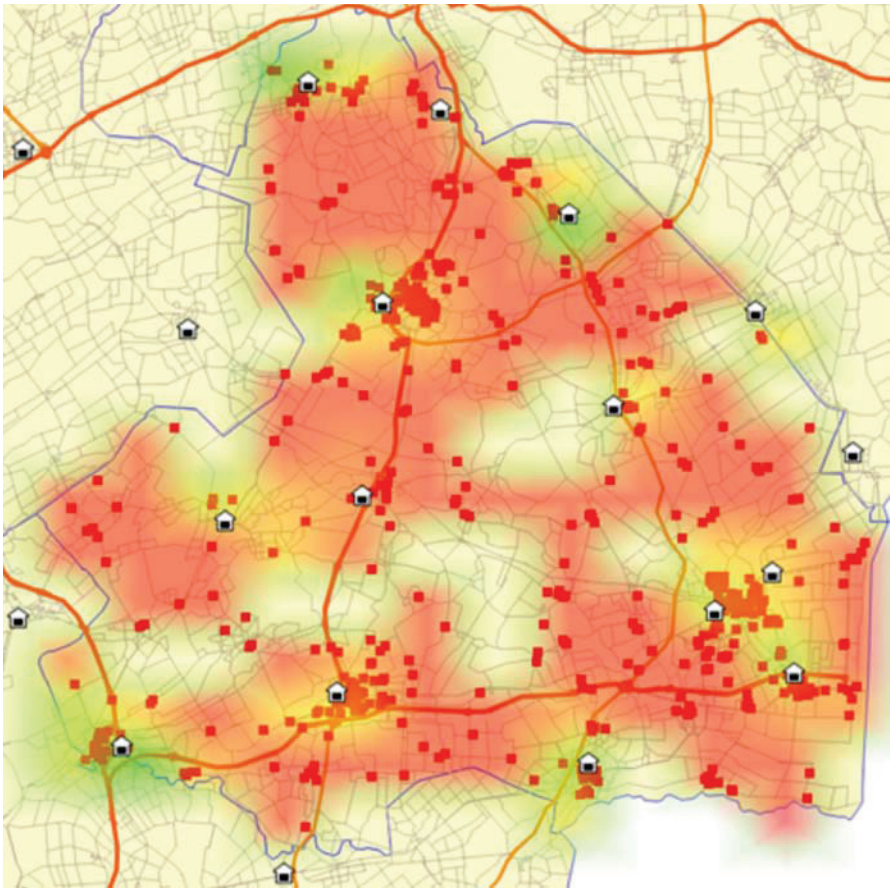

Figure 3: EMS responsiveness to calls for help concerning an OHCA. Green zones are served within 4 minutes, whereas the red ones are not.

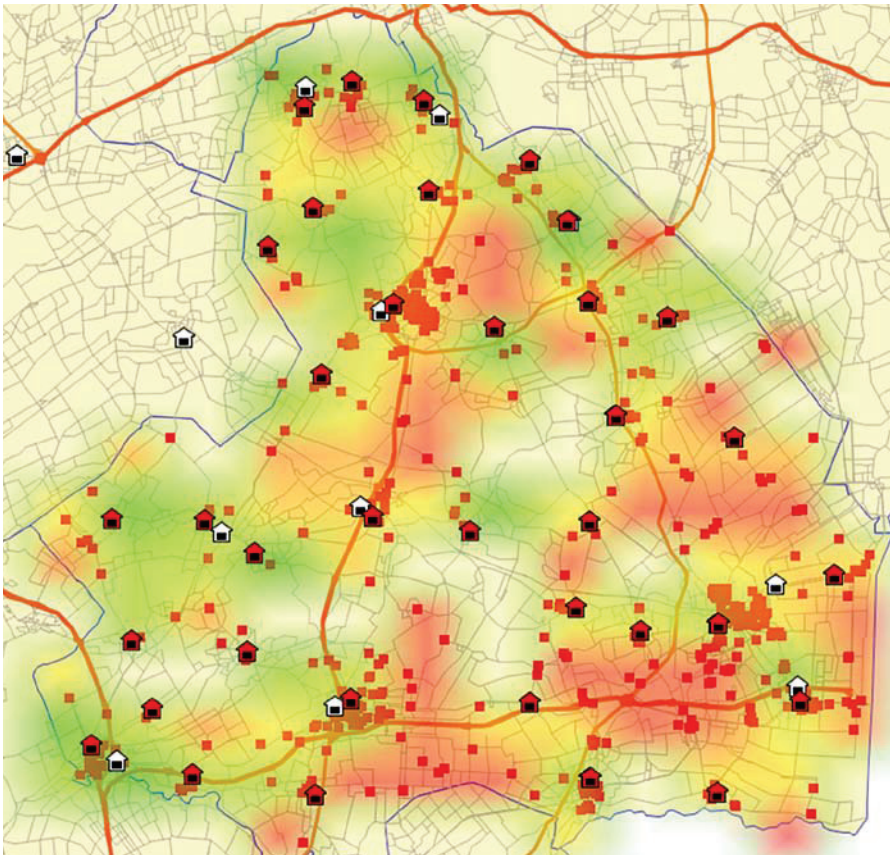

Figure 4: EMS + firefighter responsiveness to calls for help concerning an OHCA. Green zones are served within 4 minutes, whereas the red ones are not.

5.2 Volunteers

Recently, a joint cooperation of EMS providers in the Netherlands created a web-based platform named HartslagNu. Volunteers willing to give care to OHCA patients can now register themselves at this platform. Currently, 3400 volunteers are registered for the region of Drenthe, thereby creating a very dense network for serving OHCA patients. The major advantage of such a dense network is that the care- givers may be located extremely closely to patients. Possible disadvantages of utilising volunteers include their potential lack of medical skills and, on occasion, potentially unreliable response behavior. Simulation experiments for a pilot area, the urban call hotspot of Assen, show that employment of volunteers can indeed offer significant benefits. If all registered volunteers could respond to a patient to provide CPR and defibrillation, the OHCA survival rate in this urban volunteer-only system would be 16.4%. This rate assumes that advanced care arrives shortly after the patient was defibrillated by a volunteer, which is realistic in an urban setting. In an alternative scenario, in which only a quarter of the volunteers respond, but travel by bike to the victim, the survival rate increases to 20.2%. According to this scenario, 70% of the victims would be reached within 4 minutes.

5.3 Availability of AEDs

Effective treatment of OHCAs requires availability of an AED. Unfortunately, the number and distribution of registered AEDs for the region of Drenthe constitutes a bottleneck in network optimization. For example, the pilot area only has 10 AEDs at public locations. Indeed, if only those AEDs were used by volunteers and they were moved by foot towards OHCA patients, the survival rate would be just 4.9% and only 22% would be defibrillated within 8 minutes. However, doubling the amount of AEDs increases the survival rate to 8.3%. If the travel speeds were doubled to biking speed (16 km/h), the survival rate would increase even further, to 18.9%. Note that these scenarios assume a fixed mobilization time of 2 minutes: if it were 1 minute, the last scenario would yield a 24.4% survival rate, in which 97% of the people could be defibrillated within 8 minutes.

5.4 Combining networks

The solutions mentioned before consider the networks in isolation. When combining the current EMS network with firefighters and volunteers, while improving the availability of AEDs, the system survival rate could be improved to 25.8%. This number assumes that the publicly-available and registered AEDs are doubled and that volunteers respond quickly and make appropriate travel decisions. The costs of a region-wide doubling of AEDs would be €345.000.

6. CONCLUSIONS

The survival rate of OHCA patients in the region of Drenthe could be increased to the international benchmark standard of 25%. However, this survival rate cannot be attained without astronomical cost increases if only the EMS network itself is adapted. Hence, alternative networks have been considered to extend the current EMS network.

Including the firefighters network in OHCA response has shown itself to be a very cost-effective solution, in which the current survival rate of 11.5% could be increased to 17.6%. However, when the volunteer network is also included and the amount of public AEDs is doubled, the survival rate which could be achieved would help attain the target survival rate of 25%. Especially the latter one, increasing the number of AEDs, deserves special attention as this seems to be a bottleneck for increasing the survival rates.

What is next? Present research and literature suggests that combining networks would be helpful in serving OHCA patients. Although their relevance is proven, it is still largely unclear how such hybrid networks could be set-up to achieve optimal results. For example, the best number of and distribution between volunteers and AEDs is unknown. One key question which should be considered is: what would comprise the best dispatching policies for volunteers or firefighters? It is time for the industrial engineers to enter the scene, and design the optimal network in cooperation with the medics, who ultimately set the conditions for an optimal treatment.

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To find out more about Tef Jansma's research you can either email him at: tef.jansma@gmail.com or call him on: +316 106 06 524

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