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Traffic Accidents in Crete (1996-2006): the Role of the Emergency Coordination Center

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Abstract

The general decline in traffic accidents throughout Europe is not the case for Crete, a favorite holiday destination. The extent of problem and reflections on the significant impact of the interplay of organizational, educational, & technological interventions by the Emergency Coordination Center of Crete (ECC-Crete) are presented. 10-year data from 1996-2006 have been analyzed revealing demographic, topological, and qualitative issues of traffic accidents in Grete. Primary source of data is 315000 emergency calls answered by ECC-Crete. Over this 10 year period, ECC-Crete gradually employed advanced medical technologies and electronic protocol-based handling in all phases of an emergency episode contributing to its timely and effective management. GIS/GPS technology and telemetry for biosignals in ambulances, up-to-date triage protocols combined with incidence analysis provide vital information for continuous process improvement. In 2000-2006, process improvement due to technological and organizational changes has led to increased efficiency. The mean reduction was ~75% in dispatch time, ~50% in the time at accident scene for metropolitan areas, and ~75% in time at the emergency ward, mainly due to medical interventions on site.

Keywords:

Emergency management, Road accidents, eHealth Infrastructures, Technology assessment

Introduction

Traffic accidents, one the gravest problems of our times, is projected as one of the leading causes of death in 2030 by WHO [1]. Whereas all over Europe the number of traffic accidents is declining [2], in the island of Crete the problem escalates year after year. Crete is the largest island of Greece located in the center-east part of the Mediterranean. It is a popular tourist destination with a permanent population of 750,000 people rising to 1,250,000 during the 8-month long tourist season. All health-related emergency calls (166) are handled by the National Center of Emergency Response (ECC-Crete).

In the period 1995-2006, the number of vehicles using essentially the same aging road infrastructure has more than doubled. In 2005-06, 420000 motor vehicles (30% owned by rental agencies) were on the roads of Crete [3-6]. While various traffic-accident indicators for Greece decrease, this is not the case for Crete: 1248 persons lost their lives and 18901 were seriously injured in the last decade (1996-2006).

In the period 1996 to 2001, advanced Information and Communication Technologies (ICT) were gradually introduced to the day to day operation of ECC-Crete driven by organizational changes supported by systematic educational and hands-on training activities.

In the backdrop of a comprehensive analysis of the problem of traffic accidents in Crete, this paper presents elements of the operational plan of ECC-Crete, assessing the effect of the Integrated Emergency Management Information System (iEMIS) and reflecting on the interplay of organizational, educational, and technological developments.

The next section (Materials and Methods) presents elements of the operational plan of ECC-Crete and the data sources and methodology employed in this assessment. The Results section presents quantitative and qualitative results of the traffic accidents in Crete 1996-2006 focusing on quantitative evidence for their demographics and geographic locality, and qualitative evidence on the role of ICT in the effective management of emergency episodes and traffic accidents, in particular. Discussion-Recommendation outlines further interventions to contain the problem of traffic accidents that claims the life of people in their most productive age. Finally, Conclusions summarize the contribution of this work, outlining future challenges for ICT in emergency management.

Materials and Methods

Integrated Emergency Management Information System

Since 1996, iEMIS has been gradually introduced in the day to day operation of ECC-Crete to serve its primary objective, namely to improve the health outcome of those injured in emergencies including traffic accidents, through timely and effective intervention of emergency response teams. In this context, the role of ICT is central in collecting and managing relevant information providing decision support for individual emergency episodes, but also for resource planning.

iEMIS [7,8] at ECC-Crete aims to serve as the key to effective health emergency management employing state-of-the-art ICT. The basic capabilities of the iEMIS include: (a) online archive of all emergency calls and associated information; (b) geographical tracking of ambulances and mobile ICU units using Global Position System (GPS) and a Geographical Information System (GIS); (c) decision support on optimal use of the available resources; (d) acquisition, transmission, analysis, and storage of vital signs on the ambulance allowing patient telemonitoring on the way to the hospital; (e) continuous training & education of paramedics, rescuers, health professionals, and the public.

Lifecycle of an emergency episode

Every incoming emergency call at ECC-Crete is recorded on an electronic "incidence card". The incident card employs the minimal Hector data set, which was the result of consensus among many European countries in the Hector project [9]. Operator/dispatchers at ECC-Crete are responsible for initial protocol-based triage of emergency calls, dispatching of ambulances, and their follow-up. Two screens provide access to iEMIS, i.e. on-line triage protocols, GIS, and the emergency incidence database.

Once a call for a traffic accident is received by ECC-Crete, the episode is automatically geo-located on the GIS. Thus, the operator/dispatcher may promptly identify the origin of the call and the ambulances closer to the scene of the emergency. On the incident card, the operator enters all the details as provided on the phone and assigns a color code to the episode based on its severity as assessed by triage protocols: Red, Orange, Yellow, and Green. The severity of the emergency call is dictated by this color-coding with Red being that of the highest urgency. A suitable ambulance is dispatched to provide first aid and necessary medical interventions on site and transfer the victims to an appropriate medical facility. When an episode is characterized as Red, a mobile ICU manned with an emergency doctor is urgently dispatched. In Orange episodes, an Advanced Life Support (ALS) ambulance equipped with a defibrillator is dispatched, while in Yellow episodes a Basic Life Support (BLS) ambulance is dispatched. Green episodes can be scheduled with some flexibility.

Upon arrival at the scene of the accident, the medical doctor, if present, and the paramedics use radio communication and telemonitoring of the patient's vital signs and ECGs. The incidence card remains "open" until the emergency episode is received by the Emergency Ward of the medical facility.

BLS ambulances as well as mobile ICU units (ALS-MICU) have been equipped with state of the art equipment extraction, immobilization multi-trauma patients (long spine boards, «scoop stretcher», vacuum mattress, vest KED). They are also equipped with medical devices for vital signs monitors for first aid therapeutic interventions such as defibrillator, oximeter, electronic blood pressure monitors, devices for warming of liquids, intubation set, ventilators etc.

Thus, the doctor on duty at ECC-Crete can receive real-time patient tele-monitoring of the patient's vital signs and ECGs as transmitted from the ambulance. The doctor may record in the "Clinical evaluation" section of the "Incidence Card" patient condition and immediate actions. Special effort has been focused on designing this service to require minimal intervention by paramedics. In this way, the crew of the ambulance can concentrate fully on the management of emergency and the doctor receives timely information in a transparent and efficient way.

Resource management

The resource management component of iEMIS of ECC-Crete facilitates continuous evaluation of emergency services, conveying valuable insights on the management of resources and the organization of sectors (areas where ambulances are proactively deployed). Intelligent incident data analysis provides decision support at the administrative level regarding the creation of new sectors and the positioning of ambulances to improve response times. Simulation programs apply advanced data analysis methods to the contents of the emergency archive to support administrative decisions with regards to staff performance, training and scheduling, as well as the need for special equipment.

Continuing Education and Training

The personnel of ECC-Crete undergo regular training to maintain high levels of readiness and aptitude in emergency response [10]. In 2000-2006, the educational center of ECC-Crete, offered paramedics and health personnel more than 2800 hours of training certified by the Hellenic Organization of Professional Training. BLS-AED training takes place regularly based on the protocols of European Resuscitation Council (ERC). All personnel are retrained on a yearly basis on trauma management based on the principles of Advanced Trauma Life support (ATLS) and the protocols of emergency management as customized by ECC-Crete. Since 2008, a Prehospital Health Trauma Life Support (PHTLS) Center extends training to health professionals, rescuers, and citizens alike. Moreover, ECC-Crete participates in a variety of tele-training programs to train health professionals and the public in Crete and the surrounding islands.

Data Sources and Evaluation Approach

Complementary data sources have been used to assess the effect of these interventions on the management of emergencies. In particular, the following sources of data have been used in this work:

- mortality data associated with traffic accidents referring to the whole island, which were collected with support from the Police and the Forensic Medicine Department of the University of Crete
- detailed outcome data on traffic accidents with severely injured only from eastern Crete (2/3 of the population), where assistance from ECC-Crete was requested
- emergency calls to which ECC-Crete responded in the period 1996-2006, all of which were recorded in the iEMIS i.e. 315000 emergency episodes.

Based on these data sources, the results section reports quantitative evidence on traffic accidents and their severity: (a) number of fatally and severely injured in traffic accidents; (b) age distribution and gender of the victims; (c) geographic lo-

cation of traffic accidents; (d) main causes of accidents: nationalities, alcohol, tourism.

Then, in an effort to assess the role and prospects of information technology in emergency management: (a) we evaluate protocol-based triage by comparing severity of the episodes as evaluated by ECC-Crete, with assessment by the paramedics on the scene, and doctors at the Emergency Ward of the hospital; (b) we measure average times in the management of emergency episodes over time to reflect on organizational, educational, and technological interventions.

Protocol-based triage of emergency Calls - trauma scores

As already mentioned, protocol-based triage of each episode begins at the time of the emergency call with the color-coding of its priority from the operator/dispatcher of ECC-Crete. The Revised Trauma Score (RTS) and the Hector Emergency Scale (HES) rate the severity of the episode at the scene of the accident and upon arrival to Emergency Ward.

RTS is a physiological scoring system, with high inter-rater reliability. It is scored from the first set of data obtained on the patient, and consists of Glasgow Coma Scale (GCS), Systolic Blood Pressure (SBP) and Respiratory Rate (RR). RTS is heavily weighted towards the GCS to compensate for major head injury without multisystem injury or major physiological changes. HES attempts to leverage vital signs information acquired through monitoring in the ambulance and transmit it to the ECC-Crete, to be visualized at the doctor's workstation. In HES, GCS and a set of four vital signs are used for the calculation of a score that expresses the current status of the patient under care. HES scores result from the addition of the severity scores (1-4) for each of the five vital signs that appear in Table 1. Note that a total score of 14 or lower indicates a critical condition. The primary treatment goal is to achieve HES Score of at least 15 as soon as possible. The HES & RTS scores are routinely compared to the initial color-coding to assess the effectiveness of protocol-based triage.

Table 1- HECTOR Emergency Score (HES)

Severity	GCS	NISBP	HR	RR	SpO_2
4	13-15	101-180	50-100	10-30	> 94
3	9-12	76-100	101-120	> 30	92-94
2	6-8	50-75 or 181-220	121-140	6-9	90-91
1	4-5	1-49 or >220	<50 or >140	1-5	85-89
0	3	0	0	0	< 85

Results

Quantitative evidence: traffic accidents and their severity

From 1996 to 2006, ECC-Crete was called to provide assistance in 18901 traffic accidents that involved one or more injured persons. Figure 1 shows that the number of heavily injured in road accidents in 1996 was 730. Since then, with the exception of 2001 (1453) and 2003-2004 (1619, 1713) the number of injured persons is steadily rising. In 2005, the number of injured is 2869 (7.8 injured per day) and 3315 in 2006. The total number of injured is higher than the population of major cities such as St. Nikolas, or Sitia in Crete. The rising trend on the number of deaths, particularly after 2004 (shown in Figure 1), is also alarming. After a short drop in 2003 (98 deaths), we reached 148 deaths in 2005.

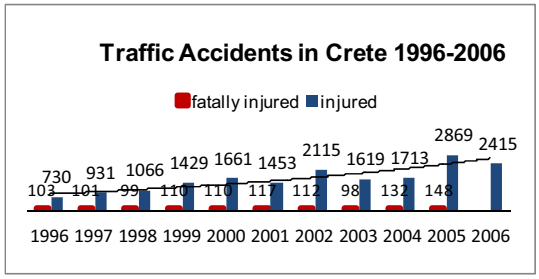

Figure 1- A rising trend in the number of fatally or heavily injured in traffic accidents. (9.4 seriously injured per day).

On the roads of Crete traffic accidents claim the lives of the young: 41% of the injured and 30% of dead are persons 17-30 years old. Moreover, 71% of the injured and 60% of the dead belong to the creative and productive ages between 20 and 50. 72% of the victims and 80% of those injured are men, compared with 28% and 20% of women, with children ranging 2-5%. Surprisingly, the number of Greeks involved in road accidents is higher than that of other nationals among fatally (85%) and heavily injured (79%). However, the tourist season pays a heavy toll in terms severely and fatally injured in traffic accidents (data not shown).

Figure 2- Location of accidents on Northern National Road.

Geographic Distribution

The largest number accidents for which ECC-Crete received an emergency call are located near the urban centers. In particular, 40% of the traffic accidents involving serious or fatal injuries were within the urban areas of Heraklion, St. Nikolas, Ierapetra, Hersonissos, and Malia. Furthermore, the number and severity of traffic accidents along the Northern National Road of Crete (NNR) and minor roads leading to the south in the Heraklion prefecture are high (20%), with the main intersections in Heraklion, claiming 10% of the total (Figure *2*).

Main causes of traffic accidents

The main causes of traffic accidents involving Greeks and other nationals differ considerably. As shown in Table 2, the most frequent cause of accidents among Greeks is violation of

traffic rules. Violation of traffic lights, high speed, and violation of priority are the top causes for severe traffic accidents involving Greeks (51%). For other nationals, the same causes of accidents account for 31%, while alcohol abuse is at the top (22%/52% for fatally injured). For Greeks, just 13% of the accidents involve alcohol abuse. Driving conditions (e.g. road conditions, light conditions) cause significant percentage of accidents to Greeks (31%) and other nationals (42%). Other nationalities are likely to drive a rented car (p=0.02) and come from countries driving on the left (p=0.02) when involved in a traffic accident. It is also worth noting the significant increase in cerebral injuries (CCS<8) among injured motorcycle drivers who did not wear a helmet (from 31 in 2000 to 195 in 2005).

Table 2- Main causes of accidents for different nationalities.

Cause of Accident	Greek	Other nationalities
Violation of traffic rules	54%	31%
Alcohol abuse	13%	22%
Alcohol abuse (among fatally injured)	35%	52%
Use of illegal substances	2%	5%
Road Conditions	31%	42%

Qualitative evidence: the role of information technology

As already noted, the aim of ECC-Crete is to improve the health outcomes of those involved traffic accidents: (a) by reducing the mean time in the different phases of handling an emergency: dispatch, access, time on site, transfer time, time in the emergency ward and (b) by employing appropriate interventions on site and en-route to the hospital to improve the RTS and HES and thus improve prospects of the emergency.

The following sections provide qualitative evidence on the effectiveness of the interplay of organizational, educational and technological interventions. iEMIS plays a central role in effectively employing technology to achieve these objectives.

Efficient handling of emergencies

Despite the increasing number of traffic accidents noted in the previous section, effective use of technology has led to a drastic reduction in the time spent at the different stages of managing an emergency episode:

- *mean dispatch time* has been reduced from 5′, 6′ in 2000 and 2001, to 1′ in 2005 and 2006 (>75%).
- *mean time to the scene* of the accident has been reduced from 10′, 12′ in 2000 and 2001 to 5′ within urban centers and in distances less than 20km (50%)
- *mean time at the emergency ward* of the hospital was reduced from 18′ in 2000 to 4′ in 2006 (>75%)

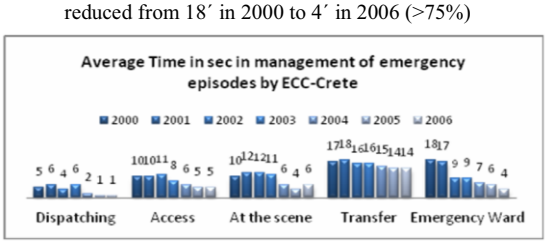

Figure 3- Response Times (sec) in emergency management

The sharp reduction in dispatch time can be attributed to iEMIS as it facilitates immediate (re)allocation of emergency resources. iEMIS provides expert assistance to operators by assessing the proximity of resources to incidents supplying scheduling data, expected times of resource availability, and accurate categorization of incident severity. The significant reduction in the mean access time can be attributed to new local sectors. ECC-Crete evaluates sector effectiveness using data mining of geolocalized incidents. New sectors were formed within the limits of urban centers and locations presenting high frequency of traffic accidents in the tourist season. Furthermore, a Special Unit of Disaster Medicine was created initially with 32 paramedics-rescuers and 4 doctors. Thus, combination of information technology, resource allocation, and training, has visible impact on the reduction of the time at the scene of the accident.

The reduction in the time spent in the Emergency Ward shown in Figure 3, can be attributed to the large number of immediate interventions at the scene of the accident. Over the last decade, the number and effectiveness of interventions on site have improved considerably both in terms of quantity and quality. Indicatively, in 2006 the iEMS database reveals that the ECC-Crete personnel have intubated after general anesthesia at the scene of the accident 95 injured persons compared to 24 in 1998. In the same time frame, 53 multi-trauma patients were extracted with the use of KED vest, collar and long spine board, compared to 8 in 1988.

Protocol based triage and color-coding of episodes

After the original color coding of the emergency episode, the health condition of the injured is regularly updated in the iEMIS database, as new values are recorded manually by ambulance crew or automatically through telemonitoring. 4680 severely injured cases were selected out of the iEMIS database, involving traffic accidents with average RTS at the critical level 9 and HES at the critical level 11. Analysis indicates that in 25% of these episodes characterised as Red or Orange in triage, response was instant and in 57% immediate. Assessment of the episodes from doctors and paramedics at the scene of the accident, showed that 31% of these episodes were characterized as RTS < 9 (mean RTS 10,04) and 26% of the episodes were characterized as HES < 11 (mean HES 14,41). Thus, there is a significant correspondence between the initial color-coding of the episodes at the time of triage and the observed severity at the scene of the accident based on the recorded vital signs. In cases where the HES score was below 15, the episode was color-coded by the dispatcher as Red or Orange, reflecting the value of iEMIS on decision support.

Discussion

Since 1869, when the first automobile fatality was recorded in a small Irish town, cars have become an integral part of our daily life. Road injuries were chosen by the World Health Organization as the focus of the World Health Day in 2004, since according to WHO resources, traffic accidents are a frequent

cause of death or a source of permanent disability. For Crete, driving conditions are grave: the 1243 fatally injured, 4680 severely injured, and 18901 injured are a quite high tall for a relatively small and closed community of 750000 people. The fact that most victims of traffic accidents are young 17-30 years old, should be a source of further concern as traffic accidents affect the most productive and vibrant part, the hope of our society. For Greek nationals, the gap in traffic education is noteworthy (31% of injured violated the traffic code), whereas for foreign nationals and tourists, alcohol is a major cause of accidents (52% of fatally injured). Nationals of countries driving on the left are involved 2.5 times more frequently in accidents that others. Driving without a helmet is critical for motorcycle drivers involved in an accident (135 in 2006).

The interventions of ECC-Crete in terms of training, education, technology, and guideline-driven procedures have positive impact. The creation of new sectors in ECC-Crete has improved overall effectiveness through improved access to the scene of the accident. Recurrent incident analysis and continuous assessment using the iEMIS database supports decision making regarding the creation of new sectors and the possible disbanding of existing ones, maintaining high operational efficiency. In terms of training and education, the recent Prehospital Trauma Life (PHTLS center) helps engage citizens, volunteers, and professional rescuers. However that is not enough, intense lessons of driver conduct to young people as part of primary education are needed, while visitors particularly those arriving from countries driving on the left should receive information or brief training before renting a vehicle.

The remarkable reduction of 50-75% in the average times of managing emergencies has lead to further thoughts regarding embracing innovation and closer collaboration with other organizations in the chain of emergency management, including not only health organizations, but also law enforcement, firefights and their disaster management units. On top of that, stronger links with primary care facilities and volunteers should be established through regular tele-education sessions based on real episodes from the iEMIS database. Innovations considered include experimenting with vehicular emergency data transmission to ECC. There are also plans for the iEMIS database that is currently episode-based to be reorganized to form a citizen-centered emergency record. That would further improve emergency management involving people of chronic conditions or special needs who are frequent or likely users of emergency services. It would assist triage by proactively supplying valuable information not only in the management of the emergency, but also to the Emergency Ward of the receiving hospital. Finally, the valuable experience reported here needs to be regularly revisited, in the frame of a long-term strategy of continuous assessment of emergency management procedures setting standards at a national and European level.

Conclusion

The island of Crete is facing a serious problem with traffic accidents, due to the ever increasing number of vehicles and poor road infrastructure. ECC-Crete has set up and continually updates its operational plan to effectively cope with increasing traffic accidents in Crete. The cooperative use of technology, training, and organization change has proved particularly effective in terms of Time, the most precious emergency resource. A major challenge for ECC-Crete is to develop and establish integrated technology-driven processes with all actors in emergency management using technological progress and innovation for better health outcomes in traffic accidents.

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