

## Prehospital Telemedicine Electrocardiogram Triage for a Regional Public Emergency Medical Service: Is It Worth It? A Preliminary Cost Analysis

Natale Daniele Brunetti, MD, PhD; Giulia Dellegrottaglie, MD; Claudio Lopriore, Giuseppe Di Giuseppe, Luisa De Gennaro, MD, PhD; Saverio Lanzone, MD; Matteo Di Biase, MD

Department of Cardiology (Brunetti, De Gennaro, Di Biase), University of Foggia, Foggia, Italy; Cardio On Line Europe S.R.L. (Dellegrottaglie, Lopriore, Di Giuseppe), Bari, Italy; Department of Cardiology (Lanzone), Hospital Di Venere, Bari, Italy

### ABSTRACT

**Background:** Telemedicine has been shown to improve quality of health-care delivery in several fields of medicine; its cost-effectiveness, however, is still a matter of debate.

**Hypothesis:** Pre-hospital telemedicine electrocardiogram triage for regional public emergency medical service may reduce costs.

**Methods:** An economic evaluation (cost analysis) was performed from the perspective of regional health-care system. Patients enrolled in the study and considered for cost analysis were those who called the local emergency medical service (EMS; dialing 1-1-8) during 2012 and underwent prehospital field triage with a telemedicine electrocardiogram (ECG) in the case of suspected acute cardiac disease (acute coronary syndrome, arrhythmia). The prehospital ECGs were read by a remote cardiologist, available 24/7. Cost savings associated with this method were calculated by subtracting the cost of prehospital triage with telemedicine support from the cost of conventional emergency department triage (ECG and consultation by a cardiologist).

**Results:** During 2012, the regional EMS performed 109 750 ECGs by telemedicine support. The associated total cost for the regional health-care system was €1 833 333, with a €16.70 cost per single ECG/consultation. Given the cost of similar conventional emergency department treatment from a regional rate list of €24.80 to €55.20, the savings was €8.10 to €38.40 per ECG/consultation (total savings, €891 759.50 to €4 219 379.50). The cost for ruling out an acute cardiac disease was €25.30; for a prehospital diagnosis of cardiovascular disease, €49.20. With 629 prehospital diagnoses of ST-elevation myocardial infarction and reported reductions in mortality thanks to prehospital diagnosis deduced from prior studies, 69 lives per year presumably could be saved, with a cost per quality-adjusted life year gained of €1927, €990/€ – 2508 after correction for potential savings.

**Conclusions:** Prehospital EMS triage with telemedicine ECG in patients with suspected acute cardiac disease may reduce health-care costs.

### Introduction

A growing burden of costs is bearing down upon health-care systems in developed countries,<sup>1–4</sup> becoming progressively less and less sustainable<sup>5–8</sup> in present international crisis scenarios. Cardiovascular disease (CVD) is one of the leading causes of death, hospitalization, and health-care expenditures in Western countries.<sup>1,9–13</sup> Several strategies have been proposed for the reduction of health-care costs.<sup>1,14–17</sup>

It is still a matter of debate whether telemedicine implementation may reduce health-care costs.<sup>18,19</sup> Prehospital

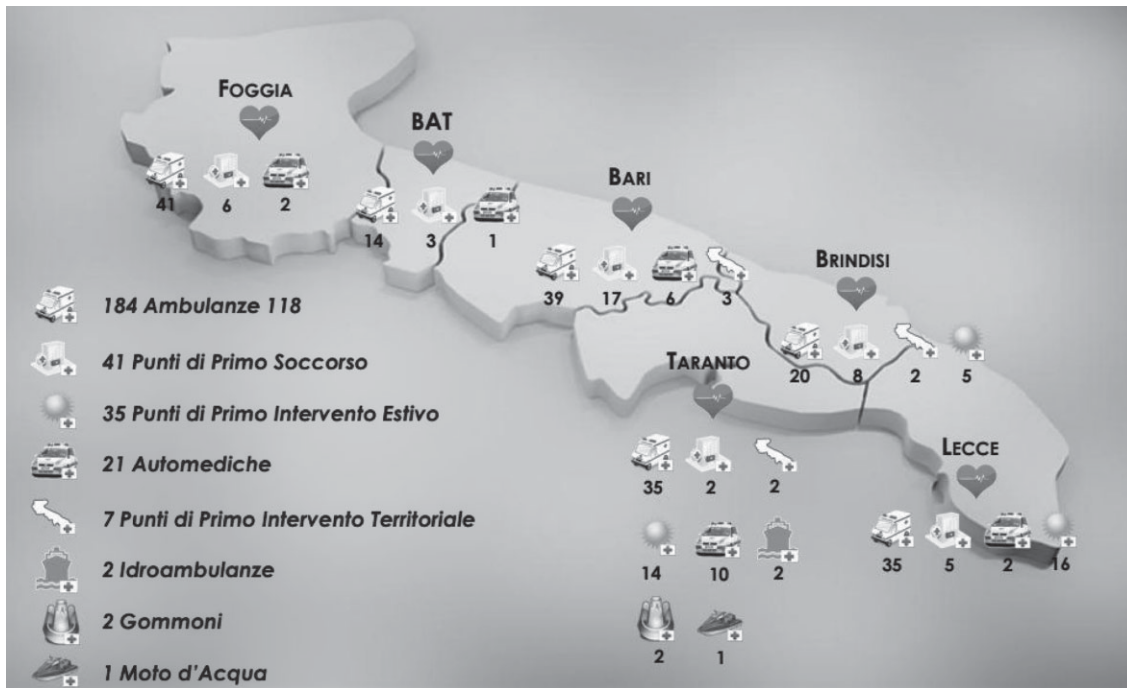
triage with electrocardiography (ECG)<sup>20</sup> and telemedicine support<sup>21–23</sup> is recommended for the implementation of telemedicine in acute CVD, even in large areas.<sup>24</sup>

We therefore report the preliminary cost analysis from implementation of a regional telemedicine service supporting the public emergency medical service (EMS) 1-1-8, the local analog of 9-1-1, in Apulia, Italy, a region with 4 million inhabitants. The region is covered by a single public health-care service, a single public EMS, and a single telemedicine service provider.

### Methods

An economic evaluation (cost analysis) was performed from the perspective of a regional health-care system that

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**Figure 1.** Distribution of local public EMS assets in Apulia, a region of Italy with 4 million inhabitants. Abbreviations: BAT, province of Barletta-Andria-Trani; EMS, emergency medical service. Legend: ambulanze, ambulances; automediche, automobile-based EMS crews (without ambulance); gommoni, seaside EMS crews equipped with rubber boats; idroambulanze, seaside EMS crews equipped with boats; moto d'acqua, seaside EMS crew equipped with personal watercraft; punti di primo intervento estivo, first-aid stations in seaside towns with summer tourists; punti di primo intervento territoriale, rural first-aid stations; punti di primo soccorso, first-aid stations.

reimburses both the costs for telemedicine support and those for 1-1-8 patients referred for emergency department (ED) assessment.

Patients enrolled in the study and considered for cost analysis were those who dialed 1-1-8 during 2012 and underwent prehospital field triage with a telemedicine ECG (109 750 on 274 198 patients who called 1-1-8 during 2012).

The telephone number 1-1-8 is the free Italian public service for general medical or surgical emergencies, whose aim is an immediate diagnosis of critical diseases to avoid ED delay to diagnosis. Final hospitalization is arranged by teams of physicians and 1-1-8 district central, connected by mobile phone; direct admission to a critical care unit is arranged according to the level of care. Patients are discharged from the ambulance and not transported at all in case of normal findings. According to Italian legislation, 1-1-8 crews usually include a physician skilled in emergency medicine and/or nurses, and any ECG preferably should be read by a cardiologist.

All crews of regional 1-1-8 EMS (more than 200; Figure 1) are therefore equipped with a CardioVox P12 12-lead ECG recorder (Aerotel, Holon, Israel). The device may record a complete 12-lead ECG, which is transmitted by mobile phone to a unique regional telemedicine support hub, located in Bari, the capital city of Apulia. The ECGs may be retransmitted back to the 1-1-8 personnel (paramedics and physicians) on smartphones connected with the telemedicine hub. Logistic support for the telemedicine hub was provided by Cardio On Line Europe S.R.L., Bari, as described elsewhere.<sup>21</sup> A cardiologist available 24/7 within

the hub promptly reads the ECGs sent by EMS personnel from all over Apulia. In case of acute CVD (acute coronary syndrome, severe arrhythmias), patients are immediately taken to the nearest acute cardiac care unit or catheterization laboratory for appropriate treatment.

Costs and rates for the analysis were retrieved from official local government reports: *Deliberazione Della Giunta Regionale*, December 15, 2009, no. 2486 (<http://www.regione.puglia.it/index.php?page=burp&opz=getfile&file=13.htm&anno=xli&num=6>) and *Nomenclatore Tariffario Regionale Per Visite Ed Esami Specialistici*, March 30, 2011 (<http://www.sist.puglia.it/opencms/opencms/portale/download/index.html>). Cost savings were calculated by subtracting the cost of prehospital triage with telemedicine support from the cost of conventional ED triage (ECG and consultation by a cardiologist). Given the different possible reimbursement codes, the cost of conventional ED triage ranged from a minimum to a maximum. The cost for a single diagnosis was calculated by dividing the total cost by the number of specific diagnoses found at prehospital triage.

The quality-adjusted life year (QALY) gain achievable after a prehospital diagnosis was deduced from prior studies. The number of additional life years gained was calculated by using an anticipated mean life expectancy of 15.41 years following thrombolysis for acute myocardial infarction (MI).<sup>25</sup> Life years gained were converted to QALYs using a mean utility value of 0.9.<sup>25</sup> The cost per QALY was then calculated.

Table 1. Costs and Savings Calculated With Implementation of Telemedicine Prehospital Triage for Public EMS 1-1-8 in Apulia, Italy (N = 109 750)

	N	Telemedicine Triage	ED Triage	
			Min	Max
Total cost		1 833 333	2 725 093	6 052 713
Total savings, min		891 760		
Total savings, max		4 219 380		
Savings per patient, min		8		
Savings per patient, max		38		
Presumed STEMI patients saved per y, n	68.56			
Presumed cost per STEMI QALY saved		1927		
Presumed cost per STEMI QALY saved, min		990		
Presumed cost per STEMI QALY saved, max		−2508		
Presumed savings per STEMI QALY saved, min		64 257		
Presumed savings per STEMI QALY saved, max		304 034		
Cost per acute CVD diagnosed prehospital		49		
Cost per excluded acute CVD diagnosed prehospital		25		

Abbreviations: CVD, cardiovascular disease; ED, emergency department; EMS, emergency medical service; max, maximum; min, minimum; QALY, quality-adjusted life year; STEMI, ST-elevation myocardial infarction.  
Unless otherwise noted, values are in euros (€) and have been rounded to the nearest euro.

The study was authorized by the local health authority and agrees with the Declaration of Helsinki.

## Results

From January 1 through December 31, 2012, regional EMS performed 109 750 ECGs by telemedicine support. The total cost reimbursed by the Apulia regional health-care system for telemedicine triage was €1 833 333, with a €16.7 cost per single ECG/consultation (Table 1).

Given a cost for similar health performance taken from regional rate list of €24.80 to €55.20, the saving was €8.10 to €38.40 per ECG/consultation (total savings, €891 759.50 to €4 219 379.50).

The cost for ruling out an acute cardiac disease (chest pain suspected for acute coronary syndrome; ST-segment elevation with possible indication of primary coronary angioplasty; atrioventricular block from grade I, type 2, to more severe blocks; ventricular malignant arrhythmias; supraventricular tachycardia; or new-onset atrial fibrillation) was €25.30, for a prehospital diagnosis of CVD €49.20.

With 629 prehospital diagnoses of acute ST-elevation myocardial infarction (STEMI) and reported reductions in mortality thanks to prehospital diagnosis deduced from recent prior studies (−10.9% absolute risk reduction),<sup>26</sup> 68.56 lives/year presumably could have been saved with a cost per QALY gained of €1927, €990/−€2508 after correction for potential savings.

## Discussion

We showed in this study potential benefits in terms of cost savings achievable with the implementation of telemedicine

support in a large regional public EMS service. To the best of our knowledge, these are among the first data on this issue.

Prior studies have shown that prehospital triage with telemedicine support could be useful in the prompt diagnosis and treatment of acute MI,<sup>21,23</sup> arrhythmias,<sup>27,28</sup> and syncope.<sup>29</sup> Prehospital ECG may allow the early detection of false-negative MI (subjects with STEMI without typical chest pain; about 20%, with increasing rates in elderly, according to some series<sup>22</sup>) and false-positive MI (subjects with chest pain without ST-segment elevation not requiring immediate reperfusion; about 96%, according to other series<sup>23</sup>) in the case of suspected acute myocardial infarction. Telemedicine might also have an important role as part of a strategy for the delivery of effective health care for patients with heart failure.<sup>30</sup>

The reduction in time to treatment and in mortality of MI has been shown by several studies.<sup>31,32</sup> In a cohort of patients scheduled for admission to a local hospital and subsequent transfer to an interventional center for primary percutaneous coronary intervention (PCI), those diagnosed prehospitally had a shorter treatment delay compared with those diagnosed in-hospital.<sup>33</sup> Transmission of a prehospital 12-lead ECG directly to the attending cardiologist's mobile telephone decreased door-to-PCI time by >1 hour when patients were transported directly to PCI centers, bypassing local hospitals.<sup>34</sup> Field triage and ED bypass reduced treatment delay in patients with suspected STEMI and resulted in smaller infarct size in early presenters and a trend toward a reduction in mortality.<sup>35</sup> Thirty-day mortality was lowest in the prehospital triage group, and there was a significant difference in long-term survival in up to 30-month

follow-up.<sup>36</sup> Every extra minute from symptom onset to reperfusion time was associated with a relative risk of long-term mortality of 1.003.<sup>37</sup> In the MonashHEART Acute Myocardial Infarction (MonAMI) project, the performance of prehospital 12-lead ECG triage and ED activation of the infarct team significantly improves door-to-balloon time and results in a greater proportion of patients achieving guideline recommendations.<sup>38</sup> After ambulance-based diagnosis of STEMI, direct transport to an intervention center with prehospital notification of the catheterization laboratory more than tripled the proportion of patients treated within the time window of the guidelines.<sup>39</sup> Prehospital triage was associated in patients with STEMI with a lower rate of severely depressed left-ventricular systolic function.<sup>40</sup> A shocking 57% reduction in in-hospital mortality was found in a recently published paper from Canada.<sup>26</sup>

The state of North Carolina has adopted a statewide STEMI referral strategy that advises paramedics to bypass local hospitals and transport STEMI patients directly to a PCI-capable hospital, even if a non-PCI-capable hospital is closer.<sup>24,41</sup>

A prehospital 12-lead ECG in cases of suspected acute MI has therefore been advocated and recommended by guidelines<sup>42,43</sup> and scientific statements<sup>44</sup>; however, its use is still low.<sup>45</sup>

By contrast, cost reduction after implementation of telemedicine technologies is still debated. A systematic review of 80 studies of the cost-effectiveness of telemedicine and telecare from 1990 to 2010, even though economic tools were being increasingly used, showed no conclusive evidence that telemedicine and telecare interventions are cost-effective compared with conventional health care.<sup>18</sup> The study was consistent with a similar study conducted in 2002.<sup>19</sup>

Evidence in favor of telemedicine cost-effectiveness is nevertheless available. In a recently published paper, a telestroke network increased the number of patients discharged home and reduced the costs borne by the network hospitals over a 5-year time horizon.<sup>46</sup> Each year, the telestroke network was associated with \$358 435 in cost savings; each spoke had \$109 080 in cost savings, whereas the hub had positive costs of \$405 121.

In a small study on 37 patients with chronic heart failure, substantial reductions in hospital readmissions, emergency visits, and cost of care were achieved by widespread deployment of distance technologies to provide posthospitalization monitoring.<sup>47</sup> Home telecare, however, did not offer incremental benefit beyond telephone follow-up and was more expensive.

In a telemedicine program in which ECG, body weight, and/or blood pressure were measured at home and medically trained personnel judged the transmitted data and counseled the patients by telephone, a €5 million per year savings with the use of such services was calculated.<sup>48</sup>

Nonetheless, other studies found improved outcomes after telemedicine implementation but incremental costs.<sup>49</sup> In a study on telephonic disease-management intervention in 1069 community-dwelling patients with heart failure, the cost per QALY gained was about \$100 000.<sup>50</sup> In a meta-analysis on 3480 patients enrolled in randomized trials designed to evaluate the effectiveness of telemonitoring

on patients with congestive heart failure, despite overall reduction in all-cause mortality and heart failure hospital admission, there was no significant difference in cost.<sup>51</sup>

There is surely a need for cost-effectiveness studies in telemedicine.<sup>52</sup> When one considers the fact that more than half a million ECGs have been sent to the Apulia regional telemedicine hub so far,<sup>53</sup> potential cost savings achievable by telemedicine support could be easily analyzed.

### Study Limitations

This is a simple observational study. The cost reduction was calculated and not documented. Costs did not consider value-added tax. Analysis on gained QALY was held only for STEMI diagnoses, which can be presumed with sufficient approximation even at prehospital triage; no data are available for non-STEMI diagnoses, which may often require serial troponin assay, not feasible in a prehospital setting.

The number of patients who would have not undergone ED triage, should prehospital triage by EMS with telemedicine support have not been operative, is unknown.

### Conclusion

Prehospital EMS triage with telemedicine ECG may be useful in reducing health-care costs.

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