

**Evaluation of neonatal transport in a European country shows that regional provision is not  
cost-effective or sustainable and needs to be re-organised**

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## **ABSTRACT**

**Aim.** There are three dedicated and 41 on-call neonatal emergency transport services (NETS) in Italy and activity levels vary dramatically. We examined the cost-effectiveness of a hub-and-spoke NETS by looking at the costs and activity levels in the Liguria region and established the financial needs for improving NETS across Italy.

**Methods.** The cost of running NETS in the Liguria region from 2012-2015 was evaluated and analysed and three different models determined the transports needed each year to provide the best organisational model.

**Results.** The average number of NETS transports in the Liguria region during the study period was 234 and the models indicated that 200-350 transports per year was the optimal amount of activity that was needed to achieve good financial performance and for the personnel to acquire a suitable skill set. Only five of the 41 on-call Italian NETS and the three dedicated services carried out more than 200 transports a year. Of the rest, 26 carried out up to 100 and 10 carried out 101-200.

**Conclusion.** Italian NETS, which is managed on the basis of regional decisional autonomy, is expensive and no longer sustainable in this era of limited financial resources. A complete overhaul is urgently needed.

**Key words:** cost, healthcare organisation, neonatal emergency transport services, newborn infants

## KEY NOTES

- There are 44 neonatal emergency transport services (NETS) in Italy and activity levels vary dramatically.
- Our study of the Italian Liguria region indicated that 200-350 transports per year were needed to achieve good financial performance and staffing skills.
- Only eight of the Italian NETS carry out more than 200 transports a year, suggesting that the current system is expensive and no longer sustainable in this era of limited financial resources.

## **INTRODUCTION**

In the 1990s (1-3), it was shown that regionalisation of perinatal care and delivery at high-volume, high-technology hospitals reduced neonatal mortality. Italy is sub-divided into 20 regions and five of these have special autonomous status. Since 1978, the Italian government has run a universal public healthcare system called the Servizio Sanitario Nazionale, which is overseen by the Ministry of Health, but run on a regional basis. Each regional government is therefore responsible for running its own healthcare system. In Italy, national health policy has long neglected regionalisation, especially with regard to perinatal care.

One example of this is the Neonatal Emergency Transport Service (NETS), which is currently controlled and organised on a regional basis. NETS is still unavailable in many parts of Italy (4,5), while several low-rate delivery hospitals, namely those with fewer than 500 births per year, still active run an active NETS.

The Italian welfare system guarantees completely free healthcare assistance to all patients and NETS is also free of charge. There are currently 44 NETS services operating across Italy: 41 are on-call services and three are dedicated services. Of the 20 Italian regions, 12 are fully covered by NETS and three are partially covered, while there is no dedicated neonatal transport in five Italian regions. Despite these regional differences, the transport team always comprises a physician and a registered nurse who are part of the neonatal intensive care unit (NICU) team linked to NETS.

Owing to the regional organisation of healthcare, NETS are not usually not allowed to operate in different regions or across regional borders.

No data have been available with regard to the the cost impact of NETS activities in Italy. The aim of our study was to evaluate the cost of the NETS in the Ligurian region, namely the average cost for each single transport, so that we could establish the cost-effectiveness of a hub-and-spoke transportation network system of on-call NETS.

It must be stressed that the data provided in this study refers to the period between 2012 and 2015, but all that data, namely costs, staff, infrastructure and means of transportation, remained unchanged for at least 18 months after the study period ended.

## **METHODS**

### **Ligurian NETS**

Liguria is a coastal region in north-west Italy, with a population of more than 1.5 million and a average annual birth rate of 10,500 to 11,000 deliveries. NETS has existed as a hub-and-spoke system since 1995 (6). The hub has always been the Gaslini Children's Hospital, which is the coordinating centre for transporting critically ill newborn infants. The Gaslini Children's Hospital is one of the eight Italian NETS that has consistently carried out more than 200 transports per year (Figure 1) and it is operated on an on-call basis. The spoke centres are the 10 Ligurian birth centres, which all require the transfer of newborn infants with complex diseases: four are within the city of Genoa, the capital of the Liguria region, and the other six are outside the metropolitan area. Figure 1 shows the distance in kilometres from the Gaslini Hospital hub to each spoke, based on data from the Liguria transportation network (Figure 1).

### **NETS composition**

Our NETS crew is composed of a staff physician, a registered nurse and an ambulance driver. The NETS is a unit-based service that is linked to the NICU at the Gaslini Children's Hospital in Genoa, which is the only level three to four healthcare organisation in the Liguria Region. The physicians and nurses involved in the transport activity alternate between working in the NICU and for NETS. Our NETS usually uses a ground ambulance run by Croce Verde Quinto, a private provider, or an Agusta Bell 412 helicopter managed by the National Fire Brigade, which is a Governmental military corps service based at Genoa International Airport. Both the ground ambulance and the helicopter can only carry one neonatal transport incubator. Members on board the helicopter include two pilots, one flight assistant and the staff physician and registered nurse provided by NETS. All

of the transport triage decisions are made by the physician, who establishes the healthcare staffing needs and mode of transport for each call. These decisions are based on the clinical condition of the patient, the estimated travel time, depending on the distance and traffic, the weather conditions and the availability of the helicopter.

### **Financial allocation**

The medical staff are provided by the Gaslini Children's Hospital, together with the the necessary devices, such as neonatal transport incubators, ventilators, monitors, pumps, drugs and medical gas cylinders. The Hospital covers the staffing and equipment costs of the healthcare professionals, the private provider pays for the purchase and running costs of the ambulance, including the drivers, mechanical maintenance and fuel, and the State pays for the use of the helicopter.

The overall cost of the NETS service consists of two main components: the fixed costs and the variable costs. Gaslini's fixed cost components include: the healthcare professionals, namely the personnel-related costs, salaries and, when applicable, fringe benefits and costs; the purchase of the medical equipment used in the transfers, including their depreciation and replacement; the utilities; and keeping personnel up-to-date. The Gaslini Hospital's variable cost components include the disposable items, such as drugs, medical gas cylinders, consumables and laundry. The private provider's fixed cost components are their staff and the purchase, insurance and maintenance of the ground ambulance and their variable component is the total annual fuel consumption. With regard to the medical equipment and the cost of purchasing the ambulance, the costs were spread over a five-year period and we divided these figures by five to calculate the annual cost of these. The occasional use of the Government-funded helicopter was calculated as a fixed costs Because the helicopter is also used for other purposes, we used the hourly rate provided by the National Fire Brigade. Finally, it is worth noting the Italian healthcare service rules means that NETS is not able to receive funding from the regional hospitals we provide service to and our calculations did not include any reimbursement for the neonatal transport.

## Cost calculations

Given the cost components described above, the average total cost (ATC) for a single transport, , was calculated using the mathematical expression given in the formula below. FC represents the yearly fixed cost components, uVC represents the variable cost components of a single transport - regardless of whether it was inside or outside the metropolitan area - xm is the number of inside metropolitan transports, xo is the number of outside metropolitan transports, PCm is the cost of fuel for a single metropolitan transport, PCo is the cost of fuel for a single outside metropolitan transport. Each parameter was considered for each of the years covered by the study period.

$$ATC = \frac{FC + uVC * (xm + xo) + (PCm * xm + PCo * xo)}{(xm + xo)}$$

Note that ATC is a function of xm and xo. Therefore, we can use this formula to evaluate how the average cost per single transport changed when the number of xm and xo transports increased or decreased. We decided to use the values for FC, uVC and x on the basis of the last few years of activity and, in particular, for the period between 2012 and 2015, and then to estimate their average values.

The overall number of transports in 2012, 2013, 2014 and 2015 were 230, 215, 243 and 248, respectively and we used the average value of 234 transports per year during the study period in Euros (€) . The average number of transports within the metropolitan area of Genoa was 142, while outside Genoa it was 92. The average fuel costs for a single transport inside and outside the metropolitan area were €6.20 and €36.08, respectively and the total annual costs were €880.40 and €3,319.36, respectively. In order to establish how the overall cost would change if the average number of transports varied per year, we then calculated (ATC) from the above formula by performing a scenario analysis (7-9) and simulating three different scenarios. In scenario one, we increased the average number of transports per year to 365, in scenarios two and three we added

100 transports to the number of actual transports performed within and outside the metropolitan area, respectively.

## **RESULTS.**

Table 1 reports the yearly fixed and variable costs that were paid by the Gaslini Children's Hospital, the private provider and the Government. These are presented as the average costs over the four-year study period, from 2012-2015. In Table 1, the variable cost - the total annual fuel consumption of €4,200 - includes journeys inside and outside the metropolitan area it depended on both the number of transports and the distance travelled. It was evaluated separately from the variable costs. The main results are as follows: between 2012 and 2015, the average number of transports per year was 234 and five of these were carried out by helicopter. The average total distance covered by the ambulance each year was 22,350 kilometres and the average distance for each transport was 95.5km: 33km inside the metropolitan area of Genoa and 192 kilometres outside it. The average yearly total of fixed costs was €334,000 and the average unitary variable cost for a single transport was €231.61, resulting in an average cost per single transport of €1,677. More details are reported in Table 2.

On the basis of these results, and using the formula above we carried out the following calculation:  $f(x) = [334,000 + 231.61 * (142 + 92) + 6.2 * 142 + 36.08 * 92] / (142 + 92)$ . The total cost of the NETS service in the Liguria region each year was €392,397.76, meaning that each transport cost an average of €1,667. Thus, we can easily see how the average cost per single transport would change if the total number of transports inside and outside the metropolitan area increased or decreased. Figure 2 shows the difference between total costs and single transport costs. The results of the simulation according to scenarios one, two and three are reported in Table 2.

The models indicated that 200-350 transports per year was the optimal amount of activity that was needed to achieve good financial performance and for the personnel to acquire a suitable skill set.

Our research also showed that the majority of NETS operating in Italy have a low rate of transports per year. Of the 41 on-call NETS, three carried out fewer than 20 transports per year, seven carried out between 21 and 40, ten between 41 and 80, six between 81 and 100 and a further 10 between 101 and 200. Only five on-call NETS – including the Liguria service studied here - carried out more than 200 transports per year. The remaining three dedicated services carried out more than 200 transports per year, according to data from the Transport Study Group of the Italian Society of Neonatology (Figure 1).

## **DISCUSSION**

The Italian welfare system guarantees completely free healthcare to all residents and this includes NETS. The presence of NETS throughout the country is based on regional political decisions and is not the result of national planning. Each region can decide whether they offers NETS on the basis of local needs, which may vary greatly from region to region.

NETS first became available in 1990 and three of the 44 NETs services are dedicated service and the other 41 operate on an on-call basis, including the service in Liguria????? Giving the regional governments the responsibility for organising some health services has resulted in an unfair distribution of NETS activities. Of the 20 Italian regions, 12 are fully covered by NETS, three are partially covered and five Italian do not have any NETS service. However, the various regions share some characteristics: the majority of services operate on an on-call basis and the transport team is always made up of a physician and a registered nurse from the NICU. Because NETS isa regional service it is not usually allowed to operate in different regions and cross regional borders, which means that the number of transports per year differs greatly between NETS, ranging from under 20 to over 200 (Figure 1). These results clearly represent a serious limitation towards achieving an adequate level of skills and experience, as well as a making it hard to achieve good

cost performance. Until now there have not been any Italian data on the cost of national NETS activity. On the basis of our results, we demonstrated that, while the total cost is proportional to the number of transports, the data shown in Figure 2 underline the fact that the average cost curve is inversely proportional to the increase in the number of transports. Thus, as expected, it follows that if the number of transports per year rises, the average cost for each single transport drops.

Since 41/44 Italian NETS are set up in a similar fashion - using personnel from their NICU and an external provider to operate the ambulance - we tried to identify the number of transports that minimised the average cost by analysing the curve shown in Figure 2. It appears that the NETS units that carried out a low number of transports per year derived no financial benefit from this type of service. In fact, the heavy burden of fixed costs calls for a centralised model for NETS, while beyond 350 transports the curve shows an asymptotic trend. This means that even if the number of transports continued to increase, the average cost would not drop any further. This means that approximately 350 transports per year could be considered the upper limit of transports that an on-call NETS unit should carry out in order to minimise the average cost, without increasing the overall costs.

In fact, if the number of transports increased beyond 350, the variable costs would increase more than the fixed costs. Furthermore, from a practical point of view, the situation would not be manageable with the available staff and vehicles, owing to the need to increase the number of teams from one to at least two, therefore doubling the fixed costs.

We evaluated our regional NETS organisation in Liguria and various scenarios were simulated. For example, scenario two artificially increased the number of short distance transports from hospitals inside the metropolitan area of Genoa by 100 (Table 2), without changing the number of transports from hospitals further away. We then inverted the simulation by in scenario three increasing the number of long distance transports from hospitals further away by 100 and maintaining the same number of transports within the metropolitan area (Table 2). The results show that the cost of a single transport would be almost identical, at €1,246 for scenario two and €1,255 for scenario three,

compared to €1,677, which is the figure we obtained from the 2012-2015 NETS activity data. Thus, we concluded that achieving good financial performance did not depend on where the increases in simulated transports came from, with regard to the distance from the hub, but on the number of transports that were simulated. It also appears that the number of spoke centres involved in the network was not relevant. What was important was the number of transports the hub carried out each year.

In an effort to determine the number of transports that would entail a high possibility of two simultaneous calls for NETS, scenario 1 simulated an increase in the number of transports per year to 365 (Table 2). This equated to an average of one transport per day. The result of these simulations were in line with the results shown in Table 2. In fact, the difference in the established cost between the 2012-2015 NETS activity and the simulated activity per single transport was very low. Thus, we can conclude that between 200 and 350 transports per year is the optimal amount of NETS activity required to guarantee appropriate levels of technical and clinical skills and bearable costs.

The number of births per year in the Liguria region has been stable at around 10,500-11,000 for some time and the number and delivery rates in active wards remained unchanged throughout the study period. The same is true for almost everywhere in Italy, with a stable delivery rate of about 500,000 births per year. This means that it is not very likely that this situation will change in the near future. Thus, we can conclude that the number of transports per year is also unlikely to change.

## **CONCLUSION**

Our study was the first to attempt to evaluate the financial impact of NETS activity in Italy. It clearly demonstrates that the current organisational model is unproductive and expensive. Although the personnel that are usually involved in Italian on-call NETS activities are part of the NICU staff, the high percentage of NETS carrying out a low number of transports per year (Figure 1) cannot

guarantee its staff members an adequate level of skills training. Moreover, the difference in the cost performance of NETS with different levels of activity leads us to some conclusions. The current Italian healthcare system, which is based on regional areas, is clearly unsuitable for the highly specific NETS activity. The hub and spoke transport network is conceptually valid, but considering the conditions that are needed to achieve a financially productive organization, we need to think of the spokepart as a sort of geographic macro-area network producing a minimum of 200 transports a year and a maximum of 350. We must therefore find a way to change the current political model, which is very closely linked to an administrative regional border strategy and is no longer bearable in this era of limited financial resources.

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### **List of abbreviations:**

NETS: Neonatal emergency transport service

NICU: Neonatal intensive care unit

ATC: average cost for a single transport

FC: yearly fixed cost components,

uVC: variable cost components of a single transport, regardless of whether it is inside or outside the metropolitan area

xm: number of inside metropolitan transports

xo: number of outside metropolitan transports

PCm: cost of fuel for a single metropolitan transport

PCo: cost of fuel for a single outside metropolitan transport

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## CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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#### **TABLE LEGENDS.**

##### **Table 1.**

NETS' average fixed and variable costs between January 2012 and December 2015.

##### **Table 2.**

Simulated cost variations on the basis of three scenarios.

#### **FIGURE LEGENDS.**

##### **Figure 1.**

**The hub-and-spoke model and activity of the 44 currently active NETS in Italy.**

**Panel A.** The hub-and-spoke model currently being used in the Liguria region, Italy. The letter M refers to hospitals which are within the metropolitan area of Genoa. The return trip distances in km from the hub at Gaslini Hospital are reported in the the black square box.

**Panel B.** Number of transports per year in the 44 active Italian NETS. Three NETS are provided a dedicated model and 41 NETS provide on-call services.

**Figure 2.**

**NETS total costs and average cost for a single transport.**

Sub-dividing the transports performed inside the metropolitan area from those outside the metropolitan area was necessary in order to calculate the *ATC* that included the cost of fuel consumption. However, we were more interested in the total number of transports. Thus, we report the sum of metropolitan and outside metropolitan transports in the x-axis, increasing and decreasing them in the same proportion with respect to the 2012-2015 data.

**Table 1.**

		<b>Cost description</b>	<b>€/year</b>
<b>Gaslini Children's Hospital</b>	Fixed costs	Healthcare professionals	150,000
		Purchase of transport devices (one fifth)	60,000
		Utilities	2,500
		Personnel up-dating	15,000
	Variable costs	Drugs and disposables	23,950
		Medical gas cylinders	7,550
		Consumables	2,808
		Laundry	19,890
<b>Private provider</b>	Fixed costs	Personnel	65,000
		Ground ambulance purchase (one fifth)	26,500
		Ground ambulance insurance	3,000
		Ground ambulance maintenance	2,000
	Variable costs	Total annual fuel consumption	4,200

<b>Government</b>	Occasional (calculated as fixed)	Helicopter use	10,000
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**Table 2.**

	<b>Averages 2012-2015</b>	<b>Scenario 1</b>	<b>Scenario 2</b>	<b>Scenario 3</b>
<b>Metropolitan transports</b>	142	208	242	142
<b>Transports outside metropolitan area</b>	92	157	92	192
<b>Total transports</b>	234	365	334	334
<b>Fixed costs</b>	€334,000	€334,000	€334,000	€334,000
<b>Variable costs</b>	€54,198.00	€84,539.62	€77,359.54	€77,359.54
<b>Yearly cost of fuel for metropolitan transport</b>	€880.40	€1,289.60	€1,500.40	€880.40
<b>Yearly cost of fuel for transport outside the metropolitan area</b>	€3,319.36	€5,664.56	€3,319.36	€6,927.36
<b>NETS total cost</b>	€392,397.76	€425,493.78	€416,179.30	€419,167.30
<b>Yearly cost of single transport</b>	<b>€1,677</b>	<b>€1,166</b>	<b>€1,246</b>	<b>€1,255</b>

