

Pennsylvania's Helicopter Ambulance Study

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The Pennsylvania Department of Highways is investigating the feasibility of using a helicopter as an ambulance, principally for traffic accident victims. The basic premise was that delay in bringing proper medical aid and the accident victim together could be caused by traffic congestion in urban areas and travel distance in rural areas. The study is being conducted in the Philadelphia suburban area for a period of one year.

A 4-place Bell J-2A helicopter modified to carry one litter patient and a medical attendant was leased 14 hours daily from 7 a. m. to 9 p. m.—the period when the highest percentage of traffic accidents occur. It was equipped with a litter, first-aid kit, oxygen, splints, blankets and sheets, and PA system. The crew consisted of a state policeman and pilot, both of whom received special first-aid training. The helicopter ambulance, which carried a police radio, was based at state police substations and responded to requests for emergency service via state police radio or phone. Two patrols were normally made each day during peak traffic hours. The helicopter was also used extensively for police traffic surveillance and criminal work. The crew was dispatched to 128 traffic accidents in which they airlifted victims from 38. In addition, they transported two accident victims from non-traffic emergencies to the hospital. The total time from receipt of alert to delivery of victim to the hospital averaged 20.9 minutes for the 40 airlifts. Trip time from accident scene to hospital averaged 6.0 minutes. Hospital physicians are preparing special medical reports on each injured person airlifted to determine what effect or benefit, if any, he experienced as a result of the reduced response time. Victim's reactions to being transported by helicopter were highly favorable. In only one instance in 41 did an accident victim refuse to be flown.

•THE 16 Safety Standards developed under the provisions of the Highway Safety Act of 1966 are becoming well-known. These standards cover all phases of activities affecting highway travel. They set the goals and establish the levels of performance that each state or local government must attempt to reach over the next several years.

Standard 311, Emergency Medical Services, states that:

Each State, in cooperation with its local political subdivisions, shall have a program to ensure that persons involved in highway accidents receive prompt emergency medical care under the range of emergency conditions encountered.

It was under this provision that the National Highway Safety Bureau and the Pennsylvania Department of Highways entered into a cost-share agreement to study the use of

helicopter ambulances for traffic accident victims. Cooperating with the Department of Highways in this study were the Pennsylvania State Police, the Department of Health, the Pennsylvania Aeronautics Commission and several area hospitals.

It was the basic premise that delay in getting proper medical care to the injured is caused largely by traffic density in urban areas and travel distance in rural areas.

The suburban area adjacent to Philadelphia was chosen as the study site and a contract was entered into with the firm of Copters' Inc. to furnish a helicopter properly equipped for ambulance service, to be available 14 hours daily, 7 a. m. to 9 p. m., 7 days a week for a period of one year.

A Bell Model J-2A helicopter was modified to accommodate a pilot, a medical attendant and one litter passenger (Figs. 1 and 2). It operated over a semicircular area with approximately a 20-mile radius covering 900 square miles.

The principal objective of the study was to determine how effective a helicopter ambulance could be in increasing the chances of survival of traffic accident victims. Some of the questions for which answers are sought are as follows:

1. What is the time reduction possible in getting proper medical aid to the accident victim either at the accident scene or hospital as compared to normal ambulance transportation?
2. Is this time reduction significant in preventing death or permanent disability to a severely injured person?
3. What are reactions of the injured persons being transported by helicopter?
4. Are certain types of injuries likely to be aggravated by helicopter transport thereby limiting its usefulness?
5. Are specialized types of medical equipment necessary or desirable to optimize the helicopter mode of transport?
6. What communications are necessary between helicopter, local or state police, ambulance clubs and hospitals?
7. What are the minimum desirable characteristics for the helicopter, with respect to size, range, speed and equipment?
8. To what extent do adverse weather conditions, physical obstructions or other factors prevent the helicopter from performing its function as an ambulance?



Figure 1. Bell Model J-2A, 4-place helicopter modified to carry 1 litter patient, 1 attendant and pilot.



Figure 2. Interior arrangement showing litter drop and seat for attendant.

9. How large an area can one helicopter adequately service?
10. Can a helicopter reduce the number of ground ambulances required to properly service a given area?
11. What is the cost of maintaining helicopter ambulance service as compared to regular ambulance service?
12. Should the helicopter patrol certain areas at certain times or remain at the base awaiting calls?
13. Can helicopter be assigned other functions, such as police patrol or criminal work without adversely affecting its primary mission of an ambulance for traffic accidents or other emergencies?
14. How many deaths or permanent injuries can be prevented using helicopter over a given area and/or time span?
15. Does rapid removal of accident victims permit earlier resumption of normal traffic flow?

DESCRIPTION OF STUDY

Study Design

In recent years, with the growth of computer usage, much emphasis has been placed on the systems approach technique for developing solutions to difficult problems. This usually consists of identification of problems and system requirements, development of system components or subsystems, and finally testing alternatives independently and in combination to determine the effects on the total system.

This methodology is particularly applicable to studies involving many variables such as those encountered in development of emergency care systems. These systems are composed of many interrelated components including accident detection time, emergency room facilities, availability of physicians, jurisdictional boundaries, local

habits and customs, to mention some that are in addition to the transportation mode variable.

Thus the "simple" task of evaluating one mode of transportation in relation to another mode could lead to a series of comprehensive studies reaching far beyond the original scope of this project, dissipating resources by utilizing specialists required to carry out such studies without necessarily finding the answer to the basic question, "Can a helicopter ambulance reduce deaths or effects of injuries in a civil environment as it does in a military environment?"

It was believed that answers could be found to most of the questions previously stated by practical testing. The method of approach, therefore, was to place a helicopter ambulance in service and develop, in general terms, only those studies required to find answers to those questions without the sophistication of rigorous systems analysis. These tasks included:

1. Measurement of helicopter capabilities in a civil environment through airlift of victims from both actual and simulated traffic accidents,
2. Medical evaluation of victims transported by helicopters,
3. Development of criteria of communication needs to permit optimum use of helicopter,
4. Survey and analysis of existing ambulance service within study area,
5. Analysis of accidents occurring during study year within study area,
6. Evaluation of other uses of helicopter (especially police),
7. Review of the legal status and responsibility of helicopter ambulance operating agency, and
8. Cost-effectiveness evaluation.

Location

It was hypothesized that a helicopter ambulance would be useful in reducing travel time under either of two common circumstances: (a) in heavily populated areas where

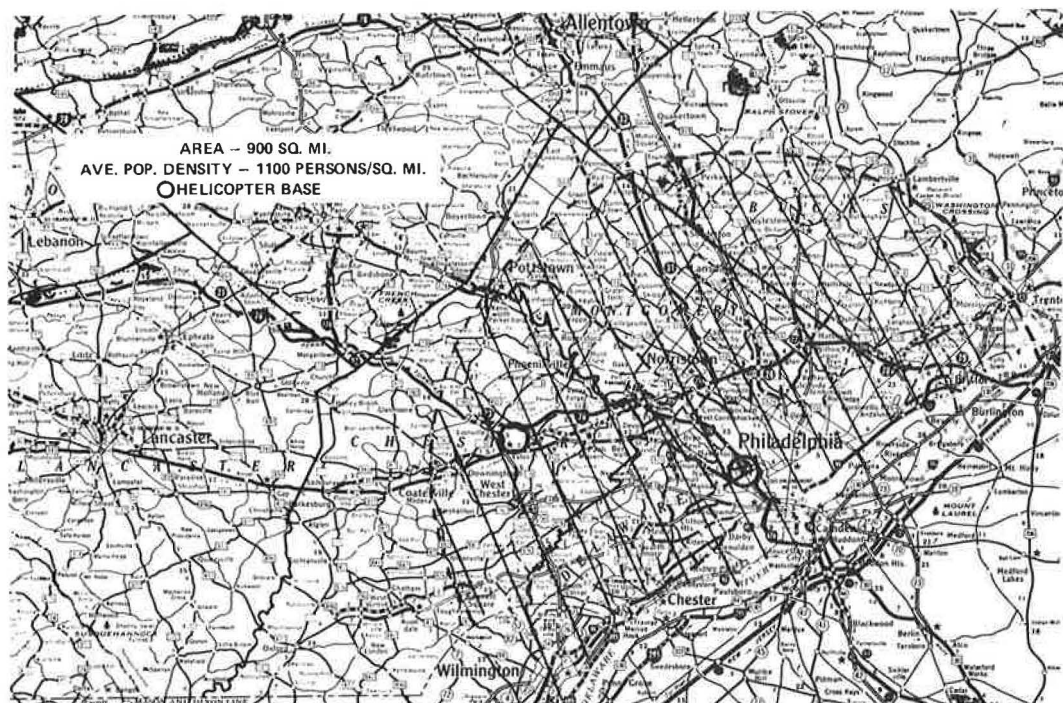


Figure 3. Southeastern Pennsylvania helicopter ambulance study area.

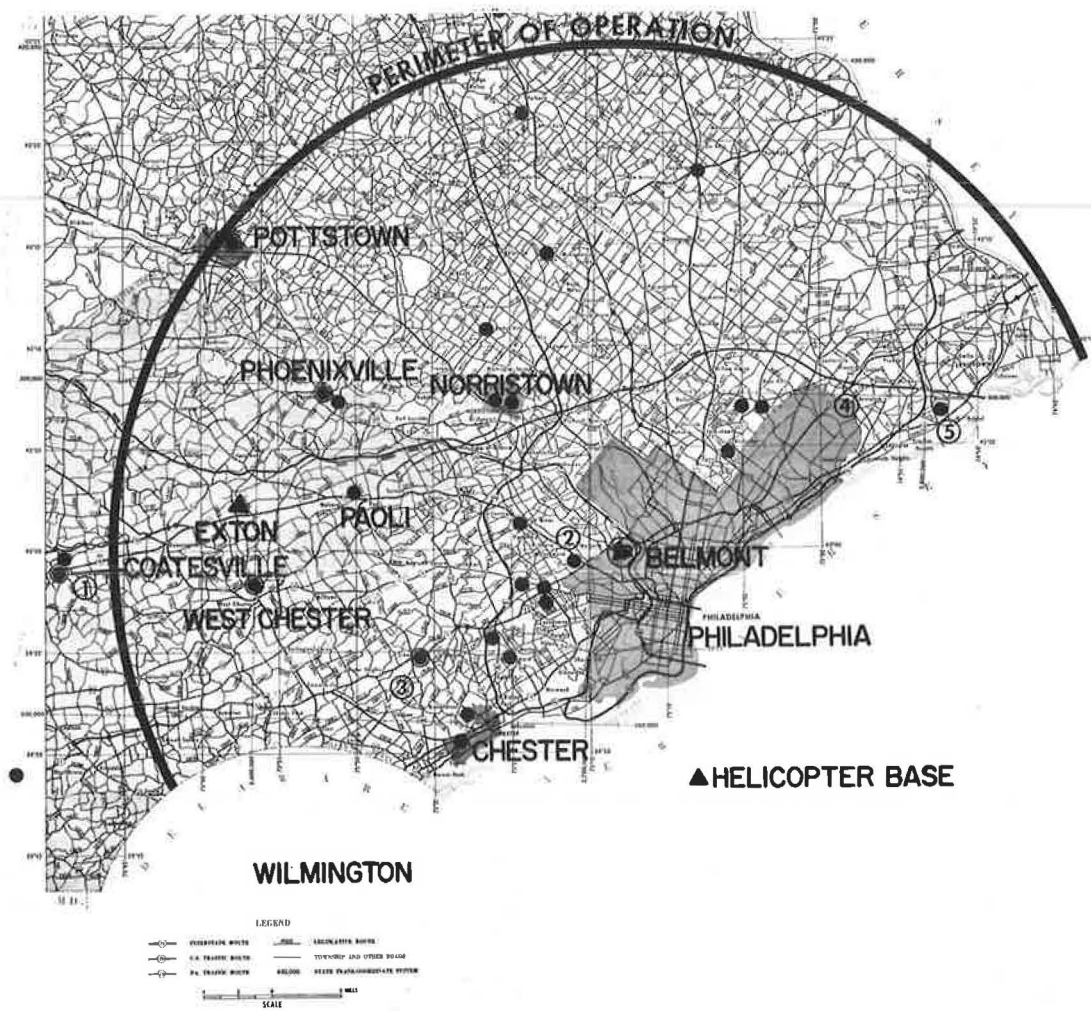


Figure 4. Locations of all hospitals in study area.

traffic density or unusual road network could delay normal ground ambulance operations, and (b) in remote rural areas where distance rather than traffic volumes prevented the ambulance from first reaching the victim and then the hospital quickly.

Since this study was to be conducted in an urban environment, the southeast corner of Pennsylvania (excluding City of Philadelphia) was selected as the study area (Fig. 3). This consists of 900 square miles encompassing the suburban Philadelphia region in Delaware, Chester, Montgomery and lower Bucks counties. This area, which has a population of just over one million persons, has an average density of 1100 persons per square mile. It includes 34,000 miles of highways and is presently serviced by 29 hospitals (Fig. 4), seven of which participated in this study (Fig. 5), and 93 ambulance companies (Fig. 6), the majority of which are volunteer.

Accident History

Approximately one-third of the 39,300 accidents that occurred in the study area during 1966 resulted in personal injuries. A cursory study of accidents occurring during December 1967, indicated an ambulance had been used in 25 percent of the injury-producing accidents. This would indicate that, on the average, 1 accident in 12 required

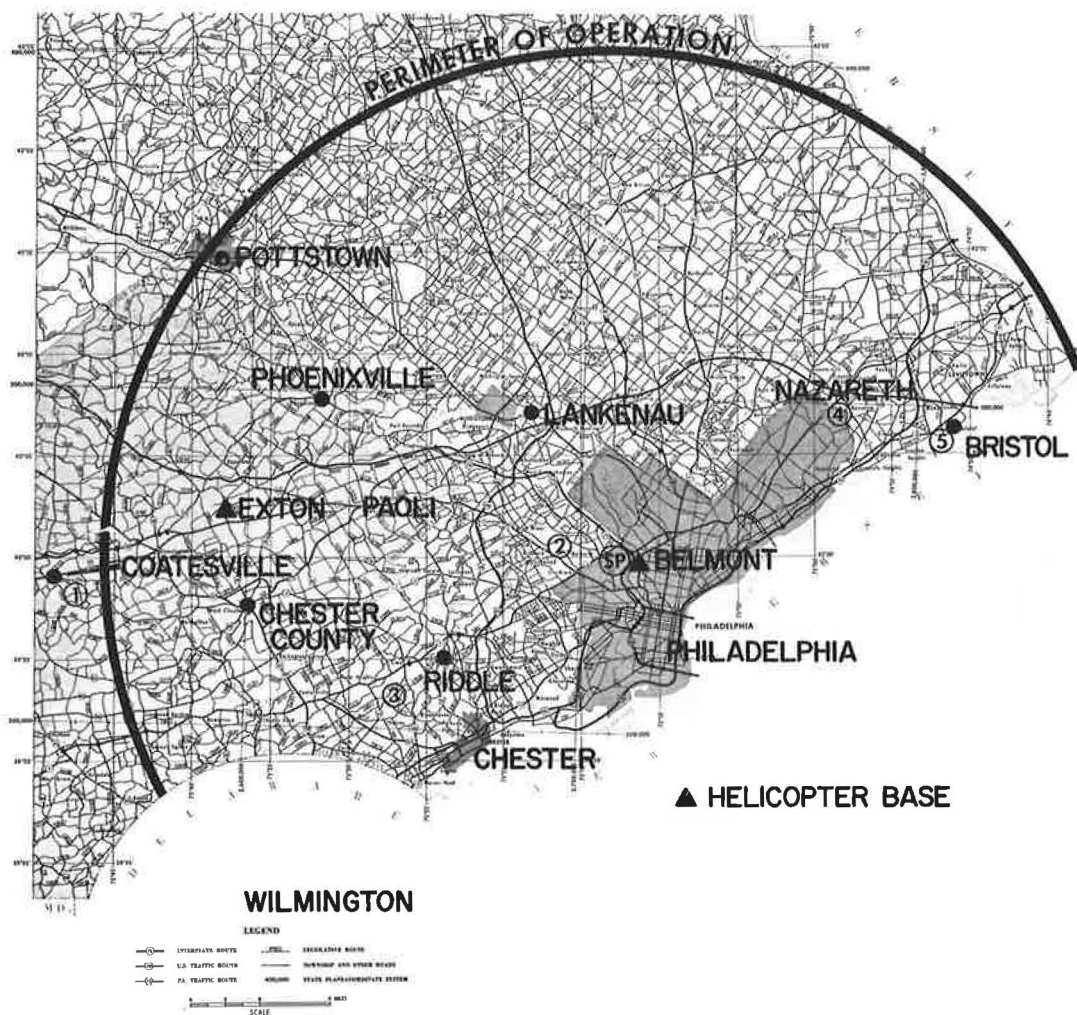


Figure 5. Locations of participating hospitals.

ambulance service. It also showed that approximately 60 percent of the accidents occurred during the 14-hr period in which the helicopter was available.

A 9-month study of accidents on 150 miles of high-volume routes in this area showed accidents occurred at rates varying between 232 and 1283 accidents per 100 million vehicle-miles. Expressed in terms of density, the rate varied between 20 and 89 accidents per highway mile. It was evident from this sampling that the accident frequency in this area was sufficient to test the helicopter ambulance (Fig. 7).

Orientation Meetings

A series of meetings was held with local police, ambulance clubs and participating hospitals to outline the objectives of the study, its relationship to the overall safety effort, and to enlist their support. Five hospitals originally were invited to participate. These were selected on the basis of their interest in the program, adequate emergency room facilities, adequate heliport, and geographical location within the study area.

A physician from the surgical staff at each participating hospital was asked to assume the responsibility for completing a medical evaluation of each accident victim admitted via helicopter. These physicians also served on a Medical Advisory Committee,

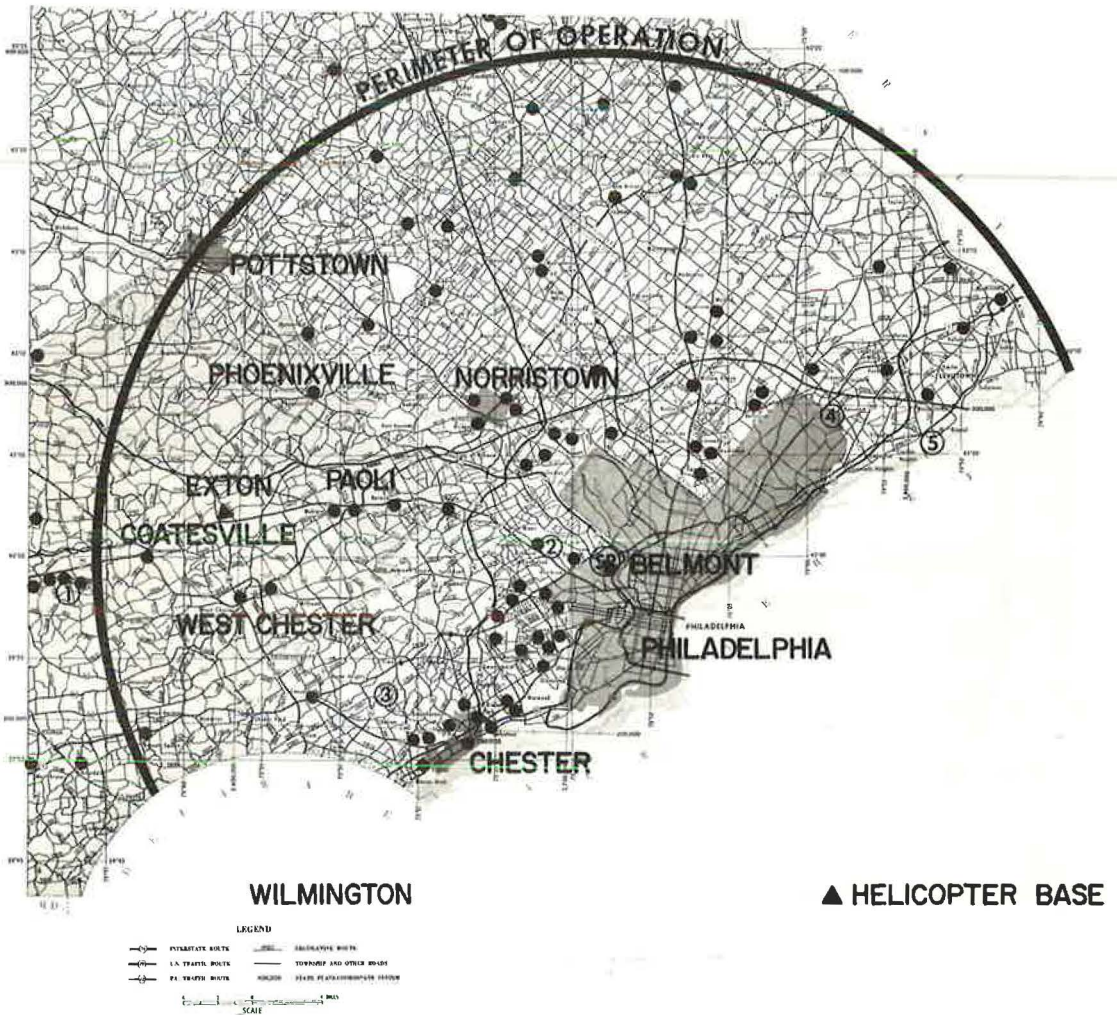


Figure 6. Existing ambulance service clubs in study area.

to provide the guidance by persons who understand the clinical needs of patients and who could suggest or evaluate equipment or procedures employed to best utilize the helicopter mode of transport in emergency situations.

Flight Crew

The helicopter was stationed initially at the western edge of Philadelphia at the Pennsylvania State Police barracks located on Belmont Avenue, between 7 a. m. and 9 p. m., 7 days a week. Seventeen troopers and three pilots were selected and given special first-aid training, which was equivalent to Advanced Red Cross and Ambulance Driver's Course. In addition, meetings were held with the troopers in which the objectives of the study were reviewed and suitable data forms developed for the recording and collecting of information required to evaluate the helicopter as a police patrol vehicle as well as an ambulance. Troopers were assigned on a rotating two-shift per day basis, 7 a. m. to 3 p. m. and 3 p. m. to 9 p. m. Flight crew consisted of a state policeman serving as a medic and a pilot with at least 3000 hours flight time.

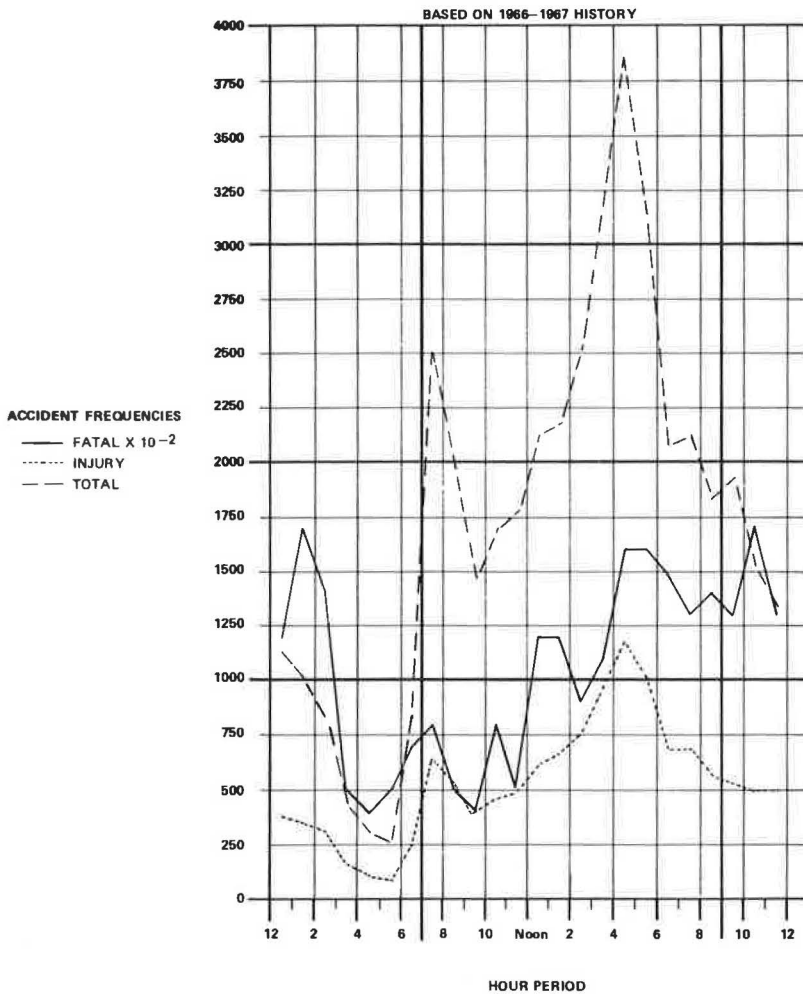


Figure 7. Average annual hourly accident frequencies Bucks, Chester, Montgomery and Delaware counties.

Mode of Operation

The following describes the operational procedures established for this study.

The need for the helicopter would be determined by the police first at the accident scene. If he were a state policeman he could communicate directly with the state police barracks by radio from his car; if he were a local policeman he would radio his headquarters who in turn would contact the state police barracks by radio or telephone. The state police would then dispatch the helicopter, which was equipped with both a state police FM radio and a VHF aircraft unit (Fig. 8). On reaching the accident scene, the helicopter would land on the highway or adjacent to it after the officer at the scene stopped traffic in both directions.

The decision would then be made whether the victim should be transported via helicopter or ground ambulance or whether the helicopter should bring a physician to the accident scene. In either event, the nearest hospital was notified by phone from the state or local police barracks of the situation after being advised by the officer at the scene. During the flight to the hospital the crew could maintain contact with the state police barracks.

Experience proved this was a sound procedure and it worked well throughout the study with few modifications.

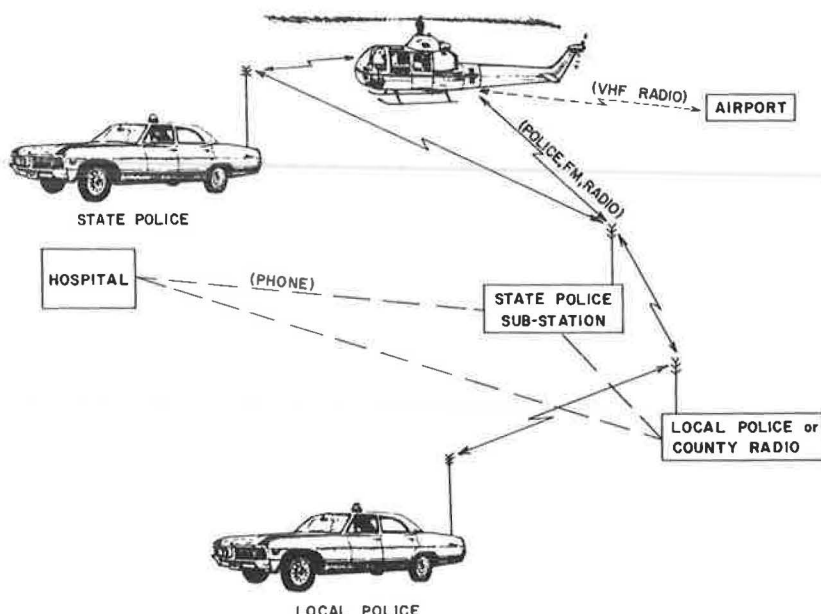


Figure 8. Communications network.

Phase I (Belmont)

The first weeks were spent principally in familiarizing the pilots and troopers with operational procedures, recognition of landmarks, physical obstructions and hospital landing sites. Patrols were flown during peak traffic periods, 7:30 to 9 in the morning and 4:30 to 6 in the afternoon. Flight schedules were not rigid, however, and some off-peak-hour patrols were also flown. The major service provided while on patrol consisted of dispatching assistance to disabled vehicles that were spotted, reporting minor accidents, and responding to varied emergencies. In one instance, a rare type of blood was rushed to an outlying hospital. In another, the helicopter served as an observation post, clearing a path and directing Highway Department salt trucks through hundreds of stalled vehicles on I-76 during a sudden icing condition.

Weather prevented flights 10 percent of the time during this study phase, which was significant because during this downtime three requests for ambulance service were received.

In view of the number of accidents that occurred, very few requests for helicopter service were received. Fourteen requests resulted in three actual airlifts, one of which was a heart attack victim. In each instance the landing, administration of first-aid, loading and transporting of the victim to the hospital were carried out smoothly and without incident. Response times were remarkably short; in one instance the total elapsed time from receipt of call at the police barracks to delivery of victim to hospital was just 9 minutes. Trip time from accident scene to hospital was 3 minutes. Normal trip time by ambulance at this hour to hospital from accident scene would have been 25 minutes.

Although 58 percent of the flights recorded a useful service of some type being performed, the lack of requests for ambulance service caused concern. Investigations indicated that 93 ambulance services were located throughout the study area, that competition between ambulance clubs in the area was high, that working arrangements between local police, ambulance clubs and hospitals had been in existence for many years, and that a general reluctance to call the helicopter prevailed unless the "spectacular" accident occurred. In the majority of instances, the police simply elected not to request the helicopter for the "normal" injury accidents that occurred so frequently. Thus, the study was suffering from a lack of necessary data required to evaluate the helicopter as an ambulance and it was a factor over which the project had little or no control.

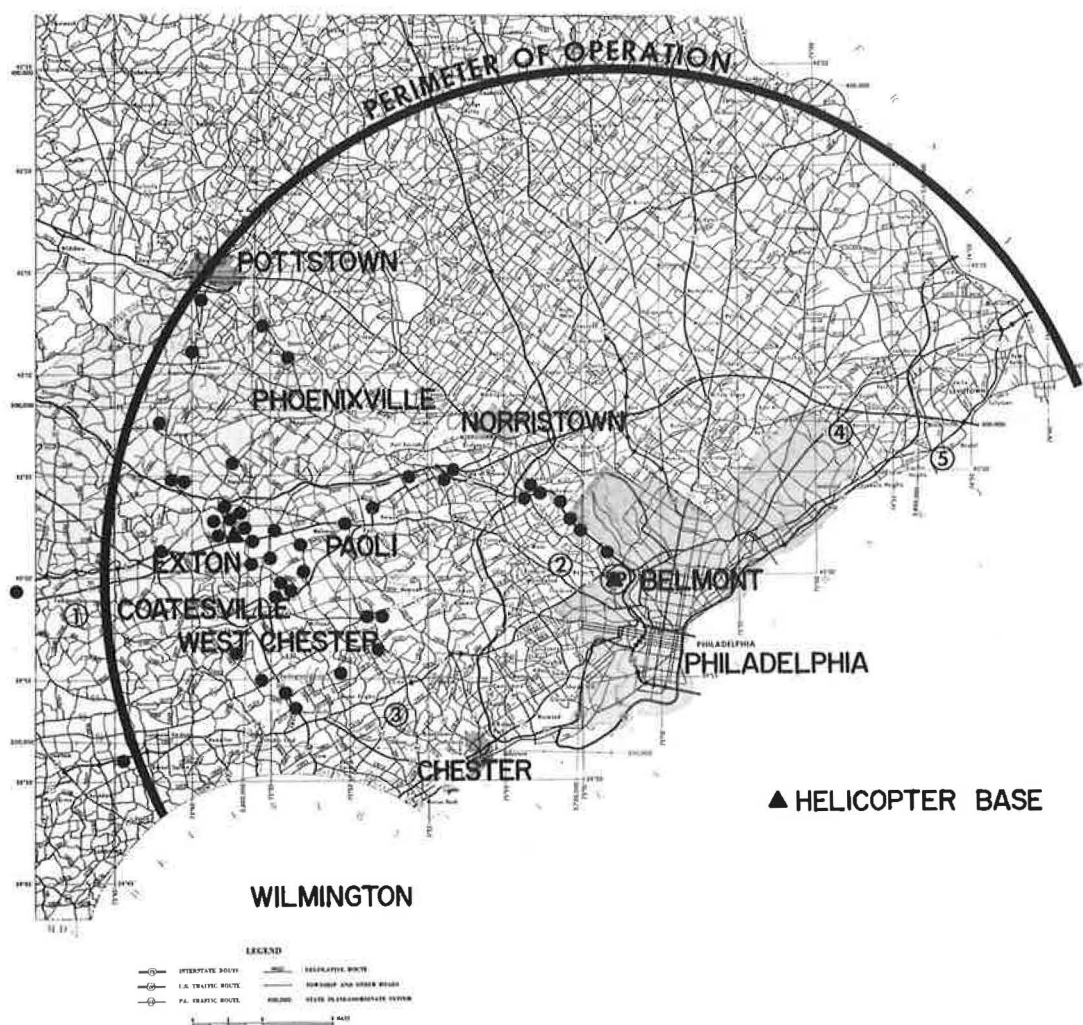


Figure 9. Locations of helicopter airlifts.

Phase II (Exton)

On March 1, the operation was transferred to the State Police Substation at Exton, which is located in the western section of the study area in a more rural environment. Four troopers were selected to fly as medics and received special first-aid training. The helicopter was identified as a police vehicle and was used more extensively in the day-to-day police operations although its primary mission continued to be an ambulance. The operation functioned in a similar manner as it did at Belmont with respect to time schedule and operating procedures, although the area of operations was generally limited to Chester County. Mutual monitoring between state police and Chester County radio network of local police radio systems resulted in more effective communications, and operation began to produce results that could be evaluated.

PRELIMINARY RESULTS

Although the flight operations for the helicopter ambulance were completed November 16, 1968, several of the study tasks are still in progress. It is possible at this time, therefore, to present a few of the results; however, they are considered preliminary.

1. During the 12 months of flight operations, the helicopter completed 622 or 85 percent of the scheduled patrols for a total of 983 flight hours.

2. The crew responded to 144 accidents (or emergencies), which resulted in completing 49 airlifts of injured or ill persons to a hospital (Fig. 9).

3. Disabled vehicles were observed on 83 patrols and investigation by the helicopter crew found that 55 percent of the vehicles required aid, which was summoned by the trooper aboard the helicopter.

4. As a police vehicle, it was dispatched to 55 criminal cases (many were bank holdups), 24 civil searches and 30 miscellaneous police activities.

5. It completed 244 (39 percent of the total) patrols in which no incidences were recorded.

6. In addition, it participated in 49 demonstrations at hospitals, schools, and ambulance club meetings.

7. It was used 9 times for engineering surveys and 15 times for airlifts at simulated accidents.

Response Time

The helicopter has proved its value in military operations in bringing the wounded to proper medical care quickly compared to ground transportation. This has also been found true in a civilian application although the environment, the operating procedures, and communications are substantially different.

For the actual airlifts completed, the total response time from initial alert to delivery of victim to the hospital averaged 20.9 minutes (Fig. 10). This is divided into four parts:

	Mean	Range (min.)
1. Alert to lift-off	2.0	1-5
2. Base to accident site	7.5	1-35
3. Time at accident site	5.4	1-48
4. Accident site to hospital	6.0	2-27

The range of times for parts 2 and 4 varied widely depending on the location of the accident with respect to the helicopter and hospital as well as wind conditions. On six occasions the helicopter was in flight at the time the alert was received.

Studies are being completed by several cooperating ambulance clubs to record their response and trip times, which will serve as a basis of comparison with the helicopter times.

Medical Considerations

The first 40 airlifts included a variety of injury types. For simplicity they have been classified as follows:

Type Injury	No. of Victims
Lacerations (head, arms, legs)	23
Fractures	3
Chest, back and internal injuries	7
Other	7

In many of the accidents the time factor in getting the victim to the hospital was not critical. However, it is often not known at the accident site whether a head or internal injury is or is not critical. Of the 40 accident victims, three had injuries that were later classed as life-threatening.

Medical supplies and equipment carried by the helicopter are rather limited as compared to a modern ground ambulance because of weight and space limitations. Specially designed equipment for helicopter usage was not available. Care of the victim by the

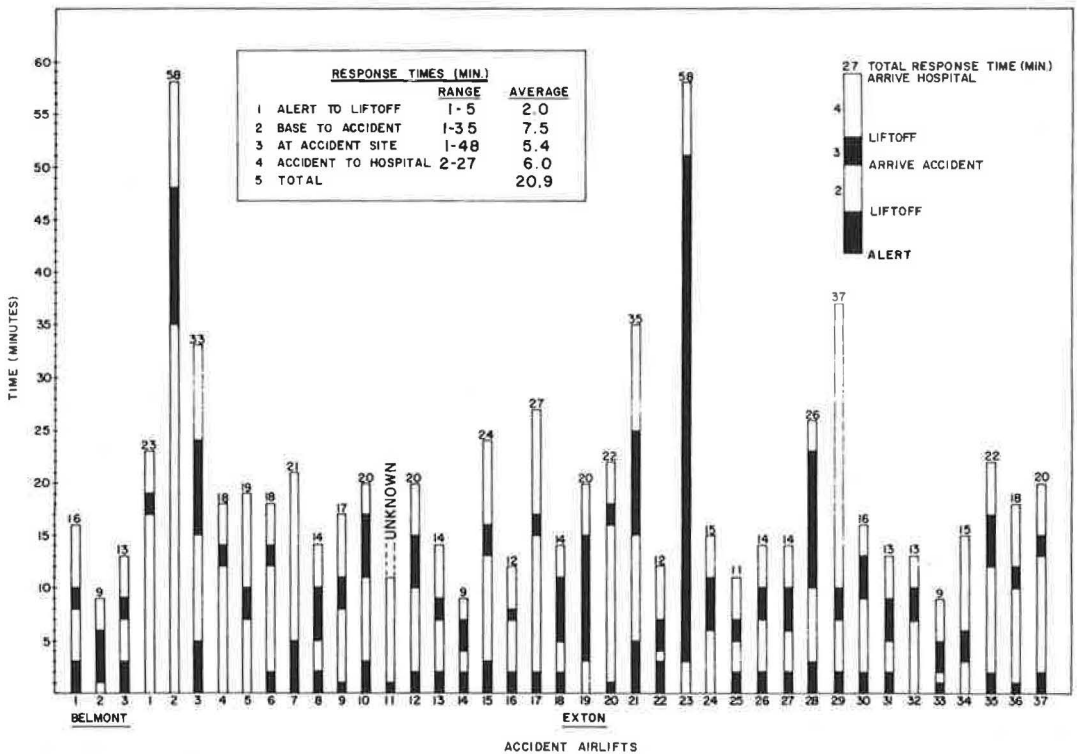


Figure 10. Distribution of trip times for accident evacuations.

attendant is also limited because of space and seat belt restrictions. External bleeding could be treated and oxygen administered; however, other resuscitation methods such as clearing air passage or external heart massage and some common methods of treating shock were extremely difficult.

The shorter trip time made possible by the helicopter, may require a new appraisal of present emergency medical techniques. In many instances there would not be sufficient time to administer treatment during the flight as is done in the ambulance.

A basic question appears to be, therefore, whether stabilization of the victim at the scene followed by a slower trip to the hospital via ambulance is more (or less) beneficial than the use of minimum first aid at the scene followed by a rapid trip to the hospital via helicopter.

The physicians who are participating in this study are considering questions such as this in addition to determining the specific benefit of the helicopter flight to those injured persons who were airlifted to a hospital.

Victim Reaction

With two exceptions, the injured person's response to helicopter transportation was one of immediate acceptance. One victim who was a University Hospital staff physician and suffered a minor injury, expressed highly favorable reaction as well as amazement at the rapid trip (in his case 3 min) to the hospital.

Although many victims were not in a condition to comment at the time of their flight, they are presently being interviewed individually to determine if they experienced any fear, ill effects or other reactions from being transported by helicopter.

For a 2-week period, the helicopter was based at a township building where it functioned as a unit in the Good Fellowship Ambulance Club. Both the helicopter and the ambulance were dispatched to accidents at the same time with a club member, in addition to the state trooper, accompanying the helicopter.

Communications under these conditions were excellent because both the township and the ambulance club were part of the county network through which all emergency calls were relayed.

During these 2 weeks the helicopter was called to 12 accidents in which seven persons were airlifted to the hospital. In addition, six simulated accident tests were conducted where both the helicopter and ambulance were dispatched at the same time. This provided an excellent means of evaluating the helicopter from the viewpoints of experienced ambulance attendants. It was possible to demonstrate the value of helicopter-ground ambulance teams working together to utilize the best capabilities of each to benefit the injured persons.

In general, the ambulance club members were highly impressed with the speed and accessibility of the helicopter; however, they regarded the space limitations, the litter arrangement and the emergency equipment carried by the helicopter as quite inferior to their ambulance vehicles.

Landing Sites at Hospitals

Although space was available at each of the seven hospitals used regularly by this study, only one had heliport facilities that had been planned previously for helicopter operation. The helicopter landing sites at the other six hospitals were usually located on reserved sections of parking lots, driveways, or lawn areas.

Each landing site, however, was checked and approved by the Pennsylvania Aeronautics Commission as having the minimum required approach clearance. Minimum standards require 8 feet horizontal clearance for each 1 foot of vertical height. Thus, an approach of 320 feet would be required to clear 40-ft trees such as existed at one hospital. The Aeronautics Commission recommends a pad of 200 feet in diameter as a desirable size for permanent heliports although none of the landing sites met this standard.

Ground delivery distance from the landing point to the emergency room entrance varied from 75 to 875 feet at the seven hospitals. Since the hospitals received prior notice of the helicopter's arrival with an injured person, they usually had personnel ready at the landing site with a wheeled litter. At Chester County Hospital, which received 23 airlifts, the local ambulance company met the helicopter and assisted taking the victims to the emergency room, 375 feet distant, using either a wheeled litter or an ambulance.

TENTATIVE CONCLUSIONS

Several areas of study vital to this project were either mentioned only briefly or were omitted entirely in this presentation because the analytic work is not complete. It will be necessary to relate the findings of this study with those of other studies (1, 2) recently completed by other agencies for the National Highway Safety Bureau.

The following general conclusions, therefore, are based on the information reviewed to date (December 15, 1968), and may be modified when the full analysis has been completed:

1. The helicopter can reduce the time required in transporting the accident victim to the hospital under conditions normally encountered on a day-to-day basis. Preliminary results show the trip may be completed in $\frac{1}{2}$ to $\frac{1}{6}$ the time required for the conventional ambulance depending on traffic flow and distances involved.

2. It has not been determined to what extent this time saving actually benefits the accident victim. Medical opinion must determine the value of time in relation to the rate of deterioration of an injured person's condition when adequate medical attention has not been provided.

3. The accident victims who were airlifted, as well as the general public, readily accepted the helicopter mode of transportation for traffic accident casualties.

4. Experienced ambulance attendants were initially skeptical about using a helicopter as an ambulance. As the study progressed, however, they gradually accepted it although it was considered by many as an auxiliary vehicle to be used only for those emergencies when a ground ambulance could not be used.

5. Adverse weather conditions prevented the helicopter from flying 15 percent of the time. After-dark usage of the helicopter is limited unless the pilot is familiar with the area being served. Thus, an effective emergency care system cannot exclude provisions for ground transportation.

6. The helicopter proved extremely useful for police activity both as a patrol vehicle in traffic surveillance and for criminal work.

ACKNOWLEDGMENT

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