THE MOBILE HOSPITAL TECHNOLOGY INDUSTRY: FOCUS ON THE CT SCANNER

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EXECUTIVE SUMMARY

The purpose of this report is to explore the nature of firms offering mobile hospital technology to rural hospitals. Specific research questions include:

1. Assuming that increasing unit volume for a mobile CT scanner reduces the average cost per scan, what factors are associated with the average number of scans per month?

2. How is the risk normally associated with a large capital outlay distributed between hospitals and mobile hospital technology suppliers?

The report focuses on the mobile CT scanner as a prevalent example of mobile hospital technology.

All mobile technology firms providing services to rural hospitals in the eight-state northwest area were surveyed by means of a telephone interview. Key findings include:

- Few firms include physicians among their investors.

- Several permanently parked CT units were found where mobile routes had atrophied due to the purchase of fixed units by former mobile CT hospital clients.

- Based on a criterion of 140 scans per month as a threshold of profitable production, units owned by larger firms (those that operate five or more units) were more likely to be profitable than units owned by smaller firms (71 percent vs. 20 percent, $p = .03$).

- A substantial number of rural hospitals lose money on mobile CT due to low levels of reimbursement from Medicare ($175 per outpatient scan, under Part B).

- In some areas, mobile hospital technology is a highly competitive industry. Evidence was found that several firms compete in some geographic areas, and that some firms have lost hospital clients to competing vendors.

Further research is needed to identify what products are being added as mobile CT routes atrophy and to assess what role, if any, mobile technology firms may play in the formation of rural health care networks.

INTRODUCTION

As rural community leaders, employers, health care providers and hospital administrators anticipate health care reform, there is uncertainty about the future of medical technology. High-cost technological services may be regionalized, yet it is not certain what form regionalization will take. If small rural hospitals are forced to refer patients needing high-technology services to regional "centers of excellence," they are likely to lose patients and revenue. An alternative form of regionalization that can keep patients in their local communities is mobile hospital technology.

Mobile hospital technology offers rural hospitals the opportunity to provide their patients with the latest in high-cost technology without the high capital costs usually associated with such equipment. Mobile equipment such as computed tomography (CT) and magnetic resonance imaging (MRI) is available in many rural areas yet absent from others (Hartley, 1993). Publications describing the industry that provides this service to rural hospitals have been limited to brief reports in trade journals (Reinhold, 1979; Fodor and Malott, 1985; Kuntz, 1985; Herman, 1986; McCue, 1989; Monk, 1988). The authors are not aware of any published analytical studies. In this report, we use 1993 survey data collected from all firms supplying mobile CT to rural hospitals in eight states as well as 1991 survey data from all rural hospitals in those states, to explore the nature of such firms: their ownership, size, methods of operation, and the factors they consider in establishing a mobile CT route. Specific research questions include:

- Assuming that increasing the unit volume for a CT scanner reduces the average cost per scan, what factors are associated with the average number of scans per month?

- How is the risk normally associated with a large capital outlay distributed between hospitals and mobile technology suppliers?

Background

Medical technology has been described as a mixed blessing: it contributes to rising health care costs, while offering hope of improved diagnosis, treatment, and health outcomes (Wilensky, 1990; GAO, 1992; Newhouse, 1993). While "medical technology" is a term that encompasses a wide variety of procedures, pharmaceuticals and devices, high-cost equipment, such as the computed tomography scanner (CT) and magnetic resonance imaging (MRI), pose a unique problem for rural hospitals. The problems rural hospitals have in acquiring new technologies have been summarized as follows:

> They have had problems incorporating new technology due to constrained capital resources, the need for specialized personnel and in-service education programs, and the difficulties associated with spreading large fixed costs over a small client base.
>
> (Moscovice, 1989, p. 923)

Lacking these new technologies, rural hospitals often must refer patients to urban hospitals or rural referral centers. These referrals result in a diversion of patients and revenue from the smaller to the larger hospital, compounding the problem by further reducing occupancy rates and financial performance in rural hospitals (Bateman, 1991).

Theoretical models of hospital behavior have often assumed that rural hospitals do not compete with urban hospitals (Lee, 1971; Luft et al, 1986; Farley, 1985). The revenue diversion resulting from technology-driven referrals, however, suggests otherwise. Moreover, by introducing rural patients to "high-tech" providers, such referrals may lead to the "bypass" or "outmigration" phenomenon, whereby the rural patient drives past the local hospital to seek services in a larger hospital at a greater distance, even when such services do not involve sophisticated technology (Jensen, 1985; Bronstein and Morrisey, 1990).

While the outmigration phenomenon assumes that the patient plays a role in the choice of hospital, it is the physician who admits the patient, and often the physician who plays the critical role in hospital choice. Thus, hospitals may address the bypass phenomenon through medical staff relations. It is generally acknowledged that medical technology plays an important role in the recruitment and retention of physicians. When a community is recruiting a new physician, the rural hospital is likely to play a major role in the recruitment process, knowing that more physicians will mean more admissions and outpatient services. As part of the recruitment effort, the hospital will often provide an inventory of its equipment and services. Digital imaging equipment such as CT and MRI is often mentioned in the recruitment effort. Thus, lack of medical technology may lead not only to lost revenue, due to referrals, but also to difficulties in recruitment and retention of medical staff and thus to diminished admissions, lower occupancy, and further revenue losses.

If a hospital chooses to purchase a costly piece of equipment, such as a CT scanner, it risks the possibility that the equipment will not be used with sufficient frequency to cover its costs. More specifically, the approximate $500,000 price tag of a new CT scanner results in debt service that must be offset by revenues from use of the equipment. In addition to debt service, the hospital incurs training and maintenance costs, which must also be covered by new revenues generated by the scanner. Moreover, the debt must be amortized over a relatively short period of time. While CT is a mature technology, and new generations of equipment offer smaller increments in quality than was the case in the mid-1980s, a four or five-year-old unit may be considered outdated by some physicians. Thus, the revenues generated must offset an accelerated rate of depreciation while covering operating costs. To increase revenue, one must increase either price or quantity (or both). The large Medicare population served by rural hospitals leaves little room for price increases, thus a fixed unit in a small hospital may create significant pressure on physicians to increase volume by ordering more procedures.

In addition, some rural hospitals lack a radiologist experienced at reading the images generated by imaging equipment such as CT and MRI. While the local radiologist may be able to gain such experience once the unit is operational, he or she will require frequent "overreads" by a radiologist with such experience during the learning period. For remote rural hospitals, finding a consulting radiologist to provide this service may be difficult. Once one is found, there may be delays in getting the results. While the technology is available for transmitting digitized images over

telephone lines, the teleradiology equipment required adds an additional cost that may exceed $100,000, and few rural hospitals have been willing to assume this additional expense (Baxter, et al, 1991; Johnson, 1992).

Against this scenario, mobile hospital technology appears to have much to offer. The hospital may need to pour a concrete slab on which to park a mobile unit and add a high voltage power source, but these start-up costs are significantly lower than the costs associated with purchase. Most mobile CT firms charge a fixed price per scan, with no apparent volume incentive to the hospital. If the mobile technology supplier offers trained technicians and radiologists as part of the service, it would appear that mobile technology has the potential to resolve most of the rural hospital's problems related to the acquisition and operation of high-cost equipment.

On the other hand, a mobile unit cannot be available 24 hours a day and thus cannot respond to most emergencies. For some mobile technologies, such as mobile lithotripsy, this will not be a problem, since procedures are scheduled in advance. For technologies that are used in emergencies, such as CT or MRI for head trauma, the limited availability of a mobile unit may be a problem.

Focus on Mobile CT

While the mobile technology suppliers surveyed for this report offer several mobile technologies, this study is focused on mobile CT. There are several reasons for this choice. In a 1991 survey of rural hospitals, mobile CT was the most prevalent mobile technology, with 45 percent of surveyed hospitals indicating that they had

mobile CT service (Hartley, 1993; See Figure 1).[1] As mentioned above, CT is a highly visible technology that may play a role in improving the hospital's reputation in its community, and in recruiting and retaining medical staff. Although MRI exhibits these same characteristics, at the time of the 1991 survey, mobile MRI was present in significantly fewer hospitals than mobile CT.

METHODS

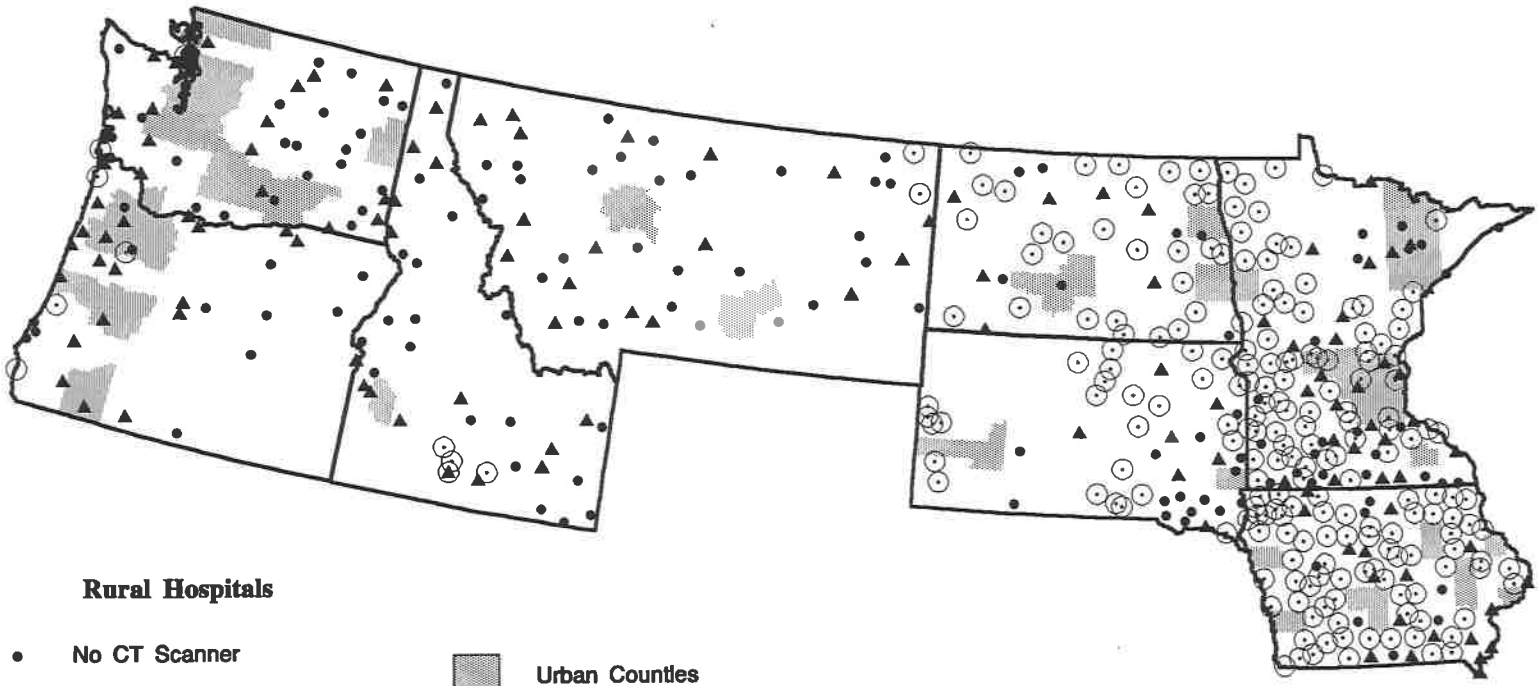
The firms interviewed for this study were identified by a two-step process. In 1991, a survey of all rural hospitals in eight northwestern states (Washington, Oregon, Idaho, Montana, North Dakota, South Dakota, Minnesota and Iowa) was conducted to investigate several issues relevant to rural health (Hartley, 1993). These hospitals were asked several questions about their technology, with a detailed section on computed tomography. Hospitals indicating that they had mobile CT were asked for the name and location of the firm providing that service.[2] Using those responses, an initial list of forty-eight firms reported to provide mobile technology in the eight-state region was developed. During the spring of 1993, each of these firms was screened by telephone for participation in the survey. To be included in the survey, we required that the firm had provided mobile CT services in 1991, was not a regional

[1]Of 472 reporting rural hospitals, 130 had no CT, 211 had mobile CT and 131 had fixed CT.

[2]For the geographical distribution of mobile CT sites, see Figure 1.

Figure 1

CT Scanners in Rural Hospitals 1991



Rural Hospitals

- No CT Scanner
- Mobile CT Scanner
- Fixed CT Scanner

Urban Counties

Rural Counties

Miles

0 200 400

Source: 1991 Rural Hospital Survey,
Rural Health Research Center,
Institute for Health Services Research
University of Minnesota

base for a larger mobile technology firm[3], and continued to provide some mobile technology services in the eight-state region in 1993.

Our initial contacts revealed that many of the firms on our list were regional bases of larger firms. Only those larger firms were included in the survey. We also found some firms that had changed their name or were using more than one name. This process led to a final list of thirteen firms,[4] two of which were subsequently found to no longer offer services in the eight-state region. For the remaining eleven firms, an administrator was identified and contacted by telephone during the summer of 1993. All eleven firms responded to the survey.

The survey instrument included questions regarding the history and ownership of the firm, services offered, staffing and maintenance, billing procedures, growth and competition, and detailed information on each CT unit operated by the firm. The following descriptive analysis includes both firm-level data and unit-level data as a means of addressing the primary research questions regarding unit volume and risk sharing. In addition, institutional data from the 1991 survey of rural hospitals are used to supplement the 1993 survey of mobile technology suppliers.

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[3]For example: If a hospital reported that it received its mobile service from Midville, Minnesota, yet our telephone contact indicated that the mobile unit operating out of Midville was owned by a firm in Centreville, the Midville firm was not surveyed, but the Centreville firm was.

[4]For example, seven different names were given by hospital respondents for a single firm in Fargo, ND. Four additional firms identified as based in Sioux Falls, SD, and one firm reported to be operating in Bismarck, ND were found to be regional bases owned by the Fargo firm. Thus, twelve firms from the original list of 48 were considered as a single firm for the study.

RESULTS

History

Among the firms interviewed for this survey, the earliest that mobile CT was offered was 1981. Mobile CT scanners were originally developed as a means for urban hospitals to avoid Certificate of Need (CON) restrictions (Reinhold, 1979). The transition from large urban hospitals seeking to avoid CON to small rural hospitals seeking to avoid large capital expenditures had begun in earnest by 1984, by which time three of the largest firms surveyed had begun operations. Early entry into the mobile technology market is not necessarily associated with current firm size, however. By 1986, eight of the firms surveyed were offering mobile CT. The four firms currently operating five or more units are included in that group. Of the remaining four, one no longer offers mobile CT, two operate only one unit, and one operates two units. On the other hand, the two most recent market entrants interviewed for this survey entered the market in 1989 and 1990 respectively and each operates only one unit.

Ownership

The ownership of the firms surveyed varied considerably but fell into three general categories: groups of private investors (not including physicians), groups of hospitals, and a combination of private investors that included physicians. Table 1 presents the number of firms falling into these categories. Two of the eleven respondents reported physicians among their investors. Three of the four largest firms in the study reported that physicians had been among their investors in the past, but

TABLE 1

OWNERSHIP OF MOBILE HOSPITAL TECHNOLOGY FIRMS

Ownership	Number of Firms
Hospitals only (one or more)	5
Investors only (no hospitals or physicians)	4
Hospitals, physicians and venture capital group	1
Physicians only	1

were no longer allowed to invest. Two of these firms indicated that they had sought other investors when expansion plans demanded larger amounts of capital than physicians were able to invest. While it was not explicitly stated that physician investors had been phased out to avoid Medicare self-referral violations, it is reasonable to conclude that the broadened interpretation of this statute in the late-1980's influenced these changes.

Within the two larger categories there is additional variation. For example, among firms with only hospitals as investors, two are groups of hospitals that have formed a network for the purpose of providing mobile technology services. One of these firms provides services only to network members, while the other provides services to two additional hospitals. One of the remaining firms in this category is a larger network of several rural hospitals and one urban hospital that was originally formed to provide a variety of services and referral relationships to its members. This firm serves both network members and non-members, and allows all hospitals to invest in either the firm or a specific piece of equipment whether or not they are network members.

Two of the investor-owned firms include employees among their major investors. One of these, the largest firm surveyed, has created an independent investment firm, which has a variety of investors including many of the drivers and radiology technicians employed by the firm.

Types of Mobile CT Routes

A mobile CT unit consists of a CT scanner installed in a semi-trailer which can be pulled by an over-the-road tractor to a number of hospital sites. The setup and tear down routines at each site take about fifteen minutes each. The CT scanner operates on 440-480 volt electrical current and most of these units are equipped with a generator. Most CT units visit more than one hospital per day, and the generator allows the crew to keep the unit "warmed up" between sites, eliminating the need for recalibrating the unit at each stop. Occasionally, the generator also allows service to a new hospital site that does not yet have a high-voltage outlet installed.

Three general patterns were observed among the CT units operated by survey respondents. The most common pattern finds the unit beginning each day of its five-day week at the same hospital, typically referred to as the "base." Three days of the week the unit begins the day with patients from the base hospital, then visits one or two other hospitals before returning to the base at night. The other days, it is driven directly to its first stop. This type of route typically serves a total of seven or eight hospitals during the week, although one unit was found to serve twelve. In general, each hospital is scheduled for one visit per week for every ten scans per month of expected demand. In the course of a month, this type of unit will perform approximately 144 scans.

A less common pattern finds the unit serving from two to five hospitals. These units may have a single base, as with the first type, or may have a second base as a

means of minimizing travel time. These units average 120 scans per month. All small hospital networks and one-unit firms exhibit this pattern.

The third pattern observed is the permanently parked unit. Although these units remain installed in a trailer, they are not functionally mobile. Many of them have had their generators removed and some no longer have tractors. These units serve only one hospital and, unlike the true mobile units, are available seven days per week. Among the four largest firms surveyed, each had at least one unit of this type. These are typically units whose multiple-site route has atrophied as hospitals on the route have purchased fixed units. When the route is diminished to one hospital, the unit is permanently parked at that hospital. Since the mobile technology firm continues to own the unit, the hospital has the benefit of full-time service without the capital costs associated with purchase of a fixed unit. These units average 73 scans per month. Characteristics of the three types of routes are presented in Table 2.

Hospitals on a few routes of the first two types have the option of unscheduled visits. Four of the firms surveyed reported that they will make unscheduled stops for emergencies if staffing and time constraints permit. In cases of head trauma, such as are often associated with an automobile crash, an emergency visit is unlikely. Since these cases are often referred to a neurologist or neurosurgeon, and few rural hospitals have such specialists on staff, these patients are more likely to be transferred immediately. Unscheduled stops are more likely to be requested when a patient's condition can be treated locally, and waiting for the scheduled visit would delay treatment. If the patient is transported to a referral hospital for a CT scan, the

TABLE 2

CHARACTERISTICS OF THREE TYPES OF MOBILE CT ROUTES

Route Type	Number of Routes	Average Number of Sites Per Unit	Average Number of Scans Per Month	Number of Profitable Units (140 or more scans per month)
High volume - multiple sites	26	8.2	144.2	19 (73.1%)
Medium volume - few sites	11	3.8	119.6	5 (45.5%)
Permanently parked	8	1.0	73.1	NA *

* Since permanently parked units have lower operating expenses, the criterion of 140 scans per month does not apply.

treatment would also be done at the referral hospital. Thus, unscheduled visits are a mechanism for avoiding the lost revenue associated with patient transfers, described previously. To assure that hospitals do not abuse the option of unscheduled stops, three of the four firms offering this option charge a higher rate per scan for such visits.

Factors Affecting Unit Volume

The need to generate sufficient volume to cover fixed costs applies to the mobile technology supplier as it does to the hospital. As the number of scans performed by a single CT unit increases, fixed costs are spread over a greater number of procedures, and the cost per scan is decreased. Achieving the lowest attainable cost per unit of output is critical when large capital costs must be amortized.

Larger firms appeared to be better able to develop high-volume routes. As an indicator of firm size, we used the number of CT units owned by the firm. Five firms surveyed operated only one CT unit, while the largest firm by this measure reported 25 units. Units owned by the four largest firms, those with five or more CT units, averaged 131 scans per month, while those owned by the remaining firms averaged 96 scans per month ($p = .065$).[5] When permanently parked units were removed from the analysis, units in larger firms averaged 142 scans per month as compared with 109 scans per month for units owned by smaller firms ($p = .063$). This finding suggests that smaller firms are less likely to make a profit from mobile CT operations.

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[5]Due to the small number of observations used for this analysis, p-values less than .10 are shown.

The CEO of one of the larger mobile CT firms indicated that 140 scans per month is a rule-of-thumb break-even point for a mobile unit. For units performing 170 or more scans per month, he reported a return to investors of 23 to 28 percent. Lacking detailed financial data, we were not able to substantiate the 140-scan-per-month threshold empirically. However, when this criterion is used (and parked units are removed), 20 percent of the units owned by smaller firms were found to be profitable, as compared to 71 percent of units owned by larger firms ($\chi^2 = 4.85$, $p = .03$).

Firms that offer many different services may also have opportunities to spread their fixed costs and reduce their costs per unit of service delivered. Three firms offered no mobile services other than CT with other firms offering as many as seven other services. No apparent relationship was observed between the two indicators of firm size: the number of CT units and the number of services offered. The two firms reporting the greatest number of CT units limit their scope of services to CT, MRI, and in one case, mammography. Two other firms operating five or more units indicated a wider range of services that included lithotripsy, ultrasound, echo cardiography, and nuclear medicine. Of the four firms with only one CT unit, two offer no other services, yet one offers four additional mobile services.

Risk Sharing

A 1986 survey of hospital administrators found that "the virtual lack of risk is inherent to the concept of mobile imaging" (Herman, 1986, p. 84). In avoiding the large capital cost of CT purchase, hospitals avoid the risk of losing money, should the

demand for CT scans fail to generate sufficient revenue to pay debt service and operating costs. On the other hand, the 1986 survey also reported that "no administrator contacted considers using a mobile CT service as a profit-generating venture" (Herman, 1986, p. 83). The motivation for hospital administrators who contract for mobile CT services does not appear to be direct profits, but instead may be related to risk avoidance and the indirect revenues associated with patient retention and enhanced MD recruitment. One administrator reported, "For us, it's market capture because we now have the capability on site and don't have to refer patients to another community for CT scans" (Herman, 1986, p. 84).

If a hospital contracts for mobile CT service at a fixed price per scan and is able to bill its patients at a higher price, it should be able to realize a profit, provided its operating expenses do not exceed this difference. In the 1991 survey, a substantial number of hospitals reported losing money on mobile CT. Such losses can be attributed to two factors. First, hospitals incur initial capital costs when they install a high voltage power outlet and a concrete slab. These relatively small capital costs, when combined with the overhead assigned to the radiology department, may generate a negative accounting profit. A second factor, perhaps of greater importance to many rural hospitals, is reimbursement for scans performed for Medicare patients. For inpatient scans, the cost of a CT scan must be covered by the DRG, while for outpatient scans, Medicare Part B reimbursement is lower than the price charged to other patients. The average charge reported by respondents to the 1991 survey was $430, while respondents reported an average charge billed to the hospital by the

mobile CT supplier of $325. Under the current Medicare fee schedule used by Blue Cross Blue Shield of Minnesota, reimbursement for one of the most common CT procedures, a brain CT without contrast, is approximately $150.[6] If the mobile CT supplier charges $325 and Medicare pays $150, the hospital loses $175 on each scan performed for a Medicare patient. When one considers that in many rural hospitals more than half of the patients seen are Medicare enrollees, it is not surprising that many hospitals lose money on CT.

In addition, a few hospitals have very low projected volume when they contract for mobile CT service. Most of the firms surveyed indicated that they rarely write contracts involving a guaranteed minimum volume. Rather than charging a higher price per scan for low volume hospitals, or requiring a hospital to pay for a minimum number of scans whether or not it can generate the demand, firms prefer to reduce the number of visits to the hospital to accommodate actual demand. Two firms indicated that they occasionally place a new client on a guaranteed minimum contract for a limited time, but only if they have reason to believe that the hospital may demand fewer than ten scans per month.

One of the firms surveyed reported that it had one unit with no regular route. This unit was leased on a per diem basis to hospitals with fixed units that were temporarily out of service, either due to repairs, upgrades or replacement. This was the only unit for which hospitals paid a daily rate, accepting the risk of losing money

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[6]Personal communication with Cynthia Thomas, Manager, Medicare Part B Participation and Reimbursement, Blue Cross Blue Shield of Minnesota. This amount was quoted for CPT Code 70450.

due to insufficient volume. One firm reported that it had test-marketed such an arrangement for MRI, but had found little interest in rural hospitals. It appears that hospitals are willing to accept the predictable losses associated with typical mobile CT contracts in preference to less predictable profits or losses associated with per diem contracts.

Staffing and Maintenance

As mentioned above, the costs associated with fixed CT include training and maintenance in addition to debt service. When rural hospitals arrange for mobile service, they relieve themselves of all three of these costs. Rather than train their radiology technician to operate a CT scanner, these hospitals rely on the mobile technology supplier to provide a trained technician. All of the firms surveyed offered this option. Since these technicians are likely to see a greater volume of CT procedures than would staff technicians in small hospitals, they may offer a higher quality service than in-house staff. In addition, many of these technicians are trained to administer the contrast media often needed for diagnostic imaging. The technicians must apply for clinical privileges for this procedure at each hospital and are generally restricted to performing the procedure only when a physician is present in the hospital. Only two of the firms surveyed did not have radiology technicians administering contrast media; both were smaller firms. None of the firms had a radiologist accompanying the units, although six firms were able to arrange for a consulting radiologist for their clients.

Several mobile suppliers also trained their drivers to perform a variety of tasks associated with the operation of the CT unit. All drivers are trained in the set up and tear down routine, including inspection of the trailer before the unit is moved. Five firms required their drivers to be certified as emergency medical technicians. One firm reported that some of their radiology technicians also have a commercial drivers license and double up as drivers, while another firm had two drivers trained as lithotripsy technicians.

The mobile firms also assume the full cost of maintenance. There are several maintenance options depending on the availability of maintenance technicians, the factory specifications for the specific unit, and the firm's ability to pay. In some areas, a GE technician is readily available, while in other areas independent maintenance contractors offer service for several brands. None of the firms is large enough to employ its own maintenance technician. Some firms have purchased maintenance contracts from the factory that provide periodic maintenance at a frequency recommended by the manufacturer. One of the smaller firms reported that it could not afford such a contract, and arranged for maintenance by a GE factory-trained technician on an as-needed basis. No relationship was observed between the number of CT units owned by a firm and the type of maintenance arrangement.

Marketing and Competition

The number of permanently parked units suggests that mobile CT may be on the decline. This interpretation was reinforced by the CEO of a mobile technology firm in the eastern U.S. that was no longer providing service in the midwest. He

questioned why we were investigating a "dying breed".[7] While mobile CT may be declining in some areas, it continues to grow in others. Three of the four firms operating five or more CT units reported at least ten new CT client hospitals in the past year. Two of these larger firms had lost clients during that period when the hospitals purchased a fixed unit. The fourth firm of this size, however, reported no new CT clients in the past year, and lost five CT clients during that period when those hospitals purchased a fixed unit. Among six smaller firms, there was one new CT client and one client that converted to a fixed unit.

Three of the four larger firms indicated active marketing, reporting that most new contracts are initiated by their managers rather than hospital administrators or physicians. In contrast, all of the smaller firms reported that new contracts are initiated by administrators or physicians at the rural hospitals. When considering a new client, most firms indicated that expected volume and the distance from current customers or bases are the major concerns. Three firms had declined to offer mobile service to a prospective client in the past year due to low expected volume. Several respondents indicated that expected volume and distance interact: they would not be willing to travel a great distance to a very low-volume hospital, but might travel as far as 200 miles to a high-volume hospital. Road quality was also mentioned as a concern by four firms. One respondent indicated that the combination of small

[7]This firm was providing mobile CT service in Iowa in 1991. When contacted in 1993, after completing part of the survey, the CEO reported that they were no longer providing any service in the midwest. The firm was therefore dropped from the analysis.

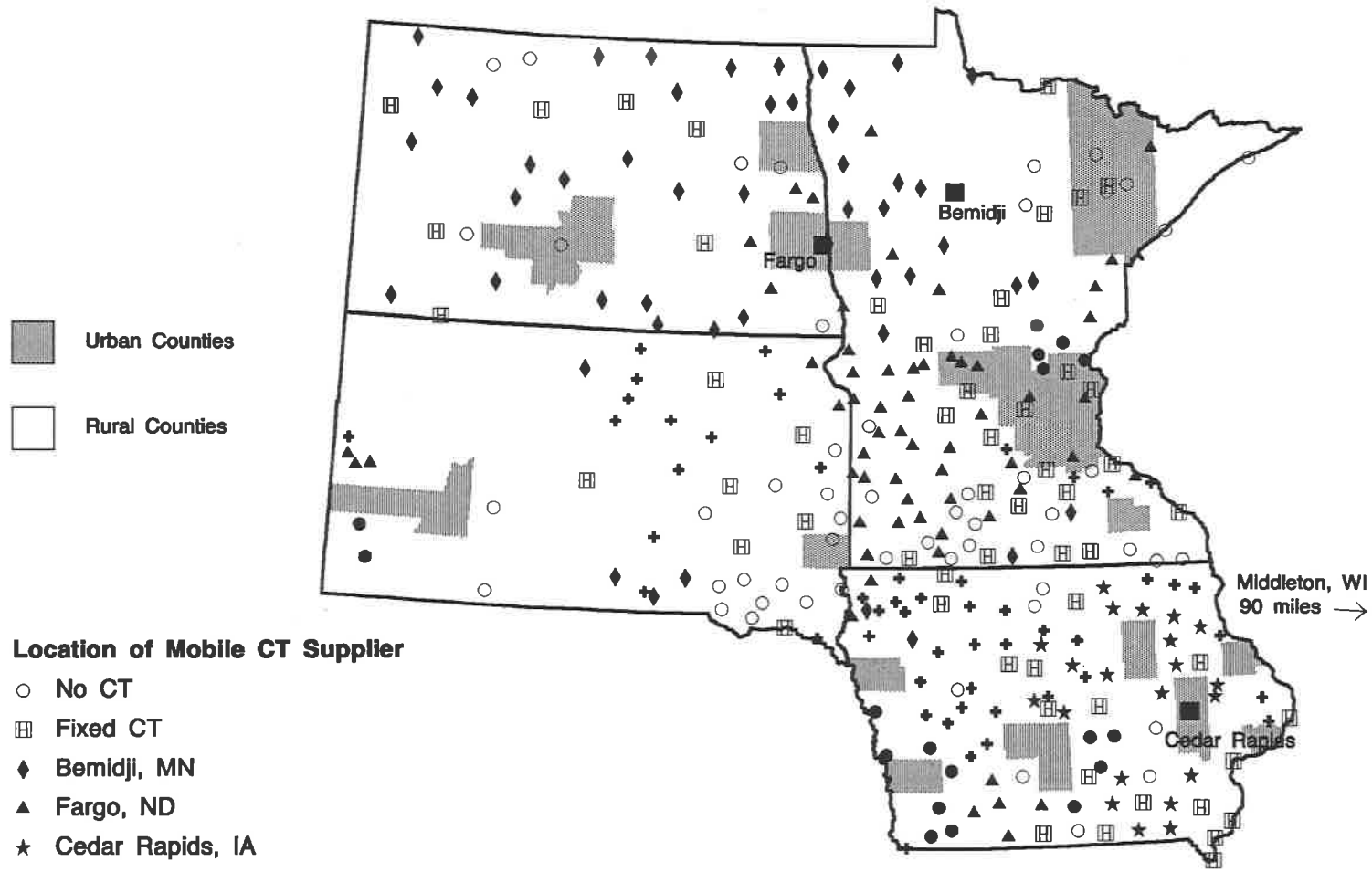
hospitals, great distances, and poor winter road conditions in eastern Oregon made it impossible to operate an efficient route in that region.

We found two indications of competition among mobile technology firms. First, using the same data from the 1991 survey that identified mobile technology firms used by hospitals, we mapped the geographic range of firms providing mobile CT service in four midwestern states (Figure 2). It is clear from this map that some of these firms are in direct competition with each other in some areas. In northwestern Iowa three different firms appear to be vying for customers, one result being that no hospital is without CT service in that region. Second, in our 1993 survey of mobile technology firms we asked respondents if they had lost any clients to a competitor in the past year. The three firms reporting in the affirmative have most of their clients in these same four midwestern states (Figure 2). While the more common reason for losing a client is the installation of a fixed unit, some firms appear to be offering incentives for a hospital to change vendors.

The larger firms surveyed appeared to be more acutely aware of the competitive nature of their business. In responding to the 1993 survey of mobile CT suppliers, two of the four firms operating five or more units chose not to report the town where each unit was based, while the smaller firms all provided this information. Thus, Figure 2 does not include the location of mobile CT bases, but only hospital sites identified in the 1991 survey of rural hospitals.

Figure 2

Rural Hospitals: Location of Mobile CT Suppliers 1991



Source: 1991 Rural Hospital Survey,
Rural Health Research Center
Institute for Health Service Research,
University of Minnesota

CONCLUSIONS

The 1991 survey of rural hospitals indicated that many of them lost money on mobile CT services. The large proportion of hospitals responding to that survey that reported having mobile CT suggests that hospitals view these losses as acceptable. It may be that the predictable losses associated with the fixed fee per scan charged by the mobile CT firm are an acceptable price to pay for risk avoidance, patient retention, and enhanced physician recruitment. Preference for mobile CT over fixed CT is more likely for smaller hospitals with greater variability in occupancy rates, and presumably in CT demand.

The eight permanently parked mobile CT units support the claim by one mobile firm administrator that mobile CT may be a declining phenomenon. On the other hand, the number of new mobile CT sites added in the past year suggests a more complex pattern. Since only larger mobile firms which have five or more units are adding new CT customers, it may be that the marketing activities of these firms are primarily responsible for this continued growth in the industry, rather than an increasing demand on the part of small hospitals and their patients. As CT has come to be considered an essential hospital service, the few remaining hospitals without CT that are within reasonable distance of these firms' current routes have been added as replacements for hospitals purchasing fixed units.

Mobile CT routes that generate fewer than 140 scans per month were considered unprofitable by the CEO of one responding firm. Units owned by larger firms were more likely to experience lower costs per scan.

While many hospitals are losing money on mobile CT services, the four larger firms surveyed appeared to be making a profit on most of their units. Since only one of these firms reported that hospitals were among its investors, it would appear that little of the direct monetary profit from mobile CT is enjoyed by hospitals, either in direct profits from patient revenues or in indirect profits generated from investments in the mobile CT firm.

We found little evidence of self-referral conflict of interest since physicians are not allowed to invest in most mobile technology firms. Most of these firms have responded to Public Law 100-93, the Medicare and Medicaid Patient and Program Protection Act of 1987, which specifies fraud and abuse and anti-kickback provisions.

Network arrangements, whereby a small group of hospitals share the purchase cost and use of a mobile CT unit, are relatively uncommon. We found two of them in this study. Each of these networks had one mobile CT unit with volume that would be considered unprofitable, based on the criterion of 140 scans per month. One of the larger firms, however, was developed by a regional network of rural hospitals with an urban hospital as a hub. This firm is operating several profitable units, and allowing hospitals to invest provides a means for these profits to return to the hospitals. Shared services are one form of rural health network activity that may be a desirable means to facilitate health care reform in rural areas (Christianson and Moscovice, 1993). While sharing a CT scanner does not guarantee the cooperation necessary to develop vertically integrated health care networks envisioned by current reform proposals, the heightened interest in such networks in rural areas suggests that

with visiting medical specialists and referral relationships, as part of their participation in urban-rural networks.

A third alternative for small rural networks is to continue contracting with existing mobile technology suppliers. Under current arrangements, large suppliers accept the majority of risk and realize the majority of the profits in dealing with individual hospitals. If networks with several rural hospital members are able to negotiate with suppliers, they may be able to transfer some of the profits associated with these technologies to the network, along with some of the risk.

Medical technology has been cited as one of the major factors contributing to escalating health care costs (Weisbrod, 1991; Newhouse, 1993; Fuchs, 1994). When rural hospitals choose between a referral arrangement with a larger hospital, purchasing a fixed technology, or contracting with a mobile technology supplier, it is not clear how these choices will affect net health care expenditures. While mobile technology may limit capital expenditures, it is generally assumed that local access to a technological procedure may increase the likelihood that a physician will order that procedure, thus increasing expenditures (Shapiro and Wyman, 1976; Baker, 1975). On the other hand, local availability may simply relocate the procedure from a referral hospital to a local hospital, with no net increase in aggregate expenditures. As rural health care networks start to assume risk under capitation arrangements, additional research will be needed to determine whether the incentives of managed care lead to cost-effective use of medical technology.

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