Factors Affecting Transportation Demand Management Program Effectiveness at Six San Francisco Medical Institutions

RICHARD DOWLING, DAVE FELTHAM, AND WILLIAM WYCKO

The effects of on-site parking management programs, transportation demand management (TDM) promotional efforts, and off-site environmental factors on the success of TDM programs at six large medical institutions in San Francisco, California, are investigated. The monthly charge for employee parking on site was found to be the single most influential factor for determining the percent of employees that drive alone to work. This single factor accounted for up to 80 percent of the variation in mode splits among the six institutions. The monthly parking charge at each medical institution was found to be highly correlated to the severity of off-site parking restrictions and the abundance of off-site transit service. These latter two factors were the next most influential factors (after on-site parking pricing) on TDM program results. These latter two factors together explain 50 percent of the variation in TDM program success among the surveyed institutions. On-site parking supply was a much less significant factor because of the availability of off-site parking in the residential neighborhoods surrounding most of the institutions. Because of the general similarity of the six institutions surveyed, the relative size and characteristics of the medical institutions were found to be the least important of the factors studied for influencing mode split success. An increase of $8.00 a month in employee monthly parking charges was found to be necessary to decrease employee drive alone mode splits by one percentage point. (The 95 percent confidence interval for this result is between $5.00 and $33.00.) The monthly parking charge is highly correlated to off-site parking and transit conditions. Consequently, to achieve the mode split improvements implied by the results of this analysis it is necessary to parallel the on-site parking charge increases with increased restrictions on off-site on-street parking and improved transit service.

The city of San Francisco generally requires that the environmental impact reports (EIRs) for improvement projects at major medical institutions include an analysis of the likely benefits of transportation demand management (TDM) programs at the institution. This analysis must take into account different levels of TDM promotional activities at the institution, the on-site parking rates charged by the institution, potential new on-site parking garages, and the presence of neighborhood residential parking permit programs on city streets surrounding the hospital campus.

Analyses of medical institution TDM programs in San Francisco have generally relied on judgmental estimates of the likely effectiveness based on limited experience with TDM programs elsewhere. The more elaborate evaluations have divided the institution's employees into different market areas (based on their residential location and distance from the institute) and estimated the potential of ridesharing and public transit incentives to attract drive-alone commuters from each different market area (*1*).

This current study evolved out of an attempt to introduce a more quantitative approach to the forecasting of TDM program effectiveness as a function of the medical institution's promotional efforts, the institution's parking management program, and the surrounding environment in which the institution is located. Six large medical institutions in San Francisco were surveyed to determine the relative influence of off-site parking restrictions, on-site parking management (supply and cost), and in-house TDM promotional efforts on employee mode split. The data were quantified and a linear regression equation was developed for use in forecasting employee mode splits.

LITERATURE REVIEW

Although there is a growing body of literature and experience on the effectiveness of TDM programs at major employers and major suburban activity centers (*2–4*), there is considerably less experience with major medical institutions.

Major medical institutions consist of a hospital surrounded by supporting medical offices, out-patient clinics, and in some cases, research facilities. Medical institutions differ considerably from the usual city center and suburban activity center employers. Medical institutions have nonstandard working hours, 24-hr operations, rotating work shifts, a high percentage of part-time workers, and a relatively high annual turnover of employees (*5*). Other large institutions, such as universities, generally don't have the 24-hr operations and rotating work shifts of medical institutions.

Sawyer and Snow (*6,7*) described the results of the First Hill Action Plan for eight medical and university institutions in Seattle. Over a 3-year period, a combined program of peak-hour express bus service, guaranteed ride home for ridesharers, and free parking days for program participants improved the drive-alone mode split at Providence Hospital from 72 to 50 percent of employees. During this period, average monthly parking charges at the eight institutions were also increased from $21 to $38. The combination of program activities prevents isolating the relative influence of the parking charges and the other TDM program components on the re-

R. Dowling, 180 Grand Avenue, Suite 995, Oakland, Calif. 94612. D. Feltham and W. Wycko, Department of City Planning, City and County of San Francisco, 450 McAllister, San Francisco, Calif. 94102.

sults. The confidentiality requirements of the participating institutions also prevented the release of more complete and detailed statistics for the study.

An FHWA report (*5*) on ridesharing strategies for medical centers describes the TDM programs and results at four institutions in Texas, Nebraska, California, and South Carolina. However, all of these results are for the period 1978 to 1980 when there was a shortage of gasoline because of the crisis in Iran.

Fink and Twitchell (*8*) conducted a major study in 1980 of the effectiveness of Transportation System Management (TSM) programs at 12 major medical and educational institutions in San Francisco. Seven of these institutions were public or private hospitals or medical centers. One employer was an insurance company. The remaining four were public or private universities.

Each institution designated a transportation broker who implemented a TSM program consisting of ridesharing promotion, transit marketing, coordination of vanpools or carpools, priority parking for vanpools or carpools, and the creation of employee transportation committees. The TSM brokers also lobbied the transit agencies for improved service. The demonstration grant program funded a central TSM coordinator, and there was a high level of management involvement in the TSM program during the 12-month period of the study.

The 1-year TSM program was effective, reducing the average percent of employees who drove alone to work from 57 to 49 percent. The average percent ridesharing increased from 17 to 22 percent. The average percent taking transit increased from 16 to 18 percent. The total number of employees driving to work alone decreased from 13,105 to 11,640 (an 11 percent decrease in solo automobile drivers) at all 12 institutions.

However, this year-long study was conducted during the height of the Iran crisis. Fink and Twitchell focused their study primarily on the effect of in-house TDM promotional activities, and neglected the effects of on-site parking management decisions and off-site environmental conditions (such as gasoline availability, on-street parking availability, and the proximity of good transit service) on TDM program results.

SURVEY DESIGN

The purpose of this study was to determine and quantify where possible the effects of institutional TDM promotional efforts, on-site parking management, and off-site environmental factors on TDM program success. The intent was to use the data to develop a methodology for forecasting the effects of various on-site and off-site actions on TDM program success.

A total of nine major medical institutions in San Francisco were contacted to obtain TDM program information and to update the information contained in the literature. Data were obtained for each institution describing its employment, patient activity, parking supply, parking rates, TDM brokerage services offered, off-site parking restrictions, transit service, and employee mode splits. Sufficiently complete data were obtained for six institutions, San Francisco General Hospital, St. Mary's, Davies, Kaiser, St. Francis, and Mt. Zion. The other three institutions either did not have available or declined to release the necessary data.

The nine institutions were selected for their general similarity in size, functions, and location so as to minimize the effects of differing employment characteristics (work hours, salaries, etc.) and global factors such as congestion on regional facilities serving each institution. Thus, only large medical institutions that are located within the city of San Francisco were selected for the survey. This ensured that on-site activities, general employment characteristics, and global environmental factors would be kept as similar as possible among the institutions surveyed.

Identification of Factors Affecting TDM Performance

Extensive practical experience in the TDM field has indicated that the effectiveness of an employer's TDM program is dependent on many different individual factors that can be grouped into on-site and off-site factors.

The on-site factors are generally under the control or influence of the employer. These factors are generally the major components of an employer's TDM program.

The on-site factors can be grouped into three categories as follows:

1. Employment characteristics,
2. Employer parking management program, and
3. Employer ridesharing and transit promotional efforts.

Employment characteristics include working hours, salaries, benefits, regularity of work schedules and location, and need for off-site business travel during the day. Except for working hours, employment characteristics are usually fixed and not subject to manipulation for the purposes of improving employee commute habits.

The employer parking management program consists of the number of spaces provided on site for employees and the monthly charge for the parking. The parking program also includes priority reserved parking and discounts for rideshare parking. On-site parking supply and pricing are recognized to be important, but there has been a general reluctance to manipulate parking supply and cost for the purposes of improving employee ridesharing and transit use.

Employer ridesharing and transit promotional efforts include marketing transit and ridesharing, information distribution, subsidies, and provision of supplemental transit services. These promotional efforts have to date received the most attention in the attempt to shift employee commute patterns.

Off-site environmental factors include those factors over which the typical employer has little or no control. These off-site factors are also recognized to be important but they are difficult to quantify. Off-site environmental factors may be grouped into localized environmental factors and global environmental factors.

Localized environmental factors affect each employer differently. Global factors tend to affect all employers in a general area in a uniform manner. Localized environmental factors include off-site parking availability, off-site parking cost; off-site transit service, and the availability of support services within walking distance (banks, copy centers, lunch stands,

and convenience stores) for errands during the day. Global environmental factors include gas price, gas availability, congestion on commute routes, tolls, automobile ownership, and automobile operating costs.

Quantification of Explanatory Variables—On-Site Factors

The medical institutions were intentionally selected to equalize as much as possible the working hours, salary levels, and other employment characteristics among the institutions. The number of employees, number of beds, and number of annual patient-days were selected as measures of the relative size and activity at each institution.

Each institution's parking management program was quantified in terms of on-site spaces, charge rates, and number of spaces reserved for carpoolers.

The level of each institution's rideshare or transit promotional effort was more difficult to quantify. Each institution's ridesharing or transit promotional efforts were compared to the city of San Francisco's draft Transportation Management Program (TMP) guidelines (see Figure 1) established by the Joint Institutional Transportation Brokers Association (JITBA) (*9*). The available documentation unfortunately allowed only yes or no answers and did not allow quantification of the intensity of effort devoted to each activity.

I. TRANSPORTATION MANAGEMENT COORDINATION

- A. Parking Management Program
  1. Spaces Controlled by Institution
  2. Parking Charge Rates
  3. Typical Parking Occupancy
  4. Reserved Spaces for Ridesharers
  5. Parking Allocation Policies
  6. Transportation Coordinator's Authority Over Parking Policy
- B. Overall Coordination and Liaison
  1. Participate in JITBA
  2. Management Coordination
  3. Liaison With City

II. TRANSPORTATION BROKERAGE SERVICES

- A. Overall Marketing Program
  1. Information Packets
  2. Promotional Materials
  3. Special Events
  4. Newsletters
- B. Public Transit Promotion
  1. Transit Pass/Ticket Sales
  2. Transit Subsidy Program
  3. Transit Information Distribution
  4. Targeted Promotional Events
- C. Ridesharing Promotion
  1. Match List Applications Distribution
  2. Targeted Promotional Events
  3. Club Bus Services
  4. Shuttle Services
- D. Flextime Promotion
  1. Constraints
  2. Potential Employee Groups
  3. Promotional Materials

III. PROGRAM EVALUATION

IV. PROGRAM GOALS AND WORK PLAN

FIGURE 1 Draft Joint Institutional Transportation Brokers Association TMP reporting guidelines.

Quantification of Explanatory Variables—Off-Site Factors

Off-site local environmental parking and transit factors were quantified in terms of the length of on-street parking time limits, and the number of transit vehicles stopping within a quarter-mile of each institution during the morning peak hour.

The number of transit vehicles per hour is admittedly a proxy variable for the general level of transit service in the area. It does not take into account route coverage, connections, and the relationship of this service to the residential location of the employees. The six institutions surveyed are all located within 3 mi of each other, and because of this close proximity, the variation of employee residential locations is not expected to be a significant influence on the quality of transit service.

Field checks were made of each of the six institutions to determine off-site parking availability and on-street parking time limits.

Most institutions surveyed were located in residential areas that had established residential parking permit programs (RPP) within the last 5 years. These programs restrict on-street parking to 2 hr with local residents allowed to purchase a sticker that allows them to park longer on the street.

Recognizing that parking time limits and residential permit programs (RPP) have different levels of effectiveness given different enforcement levels, an attempt was made to obtain parking enforcement data by RPP zone. However, the San Francisco Police Department does not track citations according to RPP zones.

Parking meters were considered to be a more effective restriction on on-street parking than the simple 2-hr zone signs used in RPP areas. Consequently, unmetered 2-hr zones were estimated to have an effective limit of 3 hr because of the less frequent patrols in these zones and the need to mark tires to verify violations.

The availability of off-site support services within walking distance of each institution was not measured. The institutions surveyed generally are essentially self-contained with on-site cafeteria services for employees, and nearby or on-site medical office buildings for physicians. Other medical support and supply services were generally beyond walking distances for virtually all the institutions. All except two of the institutions surveyed, St. Francis and Mount Zion, are located in primarily residential areas.

Measurement of Institutional TDM Program Success

The percent of employees that drive alone, share a ride, and take transit are measures typically used to evaluate the effectiveness of TDM programs. Kuzmyak and Schreffler (*3*) selected mode split as a principal criterion for their study of TDM program effectiveness. However, these three measures of mode split can conflict and confuse the determination as to the relative effectiveness of different institution's TDM programs. For example, as presented in Table 1, Davies Hospital has a better drive-alone mode split than San Francisco General Hospital (SFGH), but Davies has a poorer transit mode split than SFGH.

TABLE 1 COMPARISON OF INSTITUTIONAL TDM PROGRAM EFFORTS

	DAVIES	SFGH	ST.MARY'S	KAISER	ST.FRANCIS	MT. ZION
I. GENERAL INSTITUTIONAL CHARACTERISTICS						
A. Licensed Beds	341	582	531	323	362	439
B. Patient-Days	43,000	144,000	93,000	88,800	51,000	69,682
C. Day-time Employment	850	2,600	1,150	1,500	1,000	1,400
D. Patient-days/Bed	126.10	247.42	175.14	274.92	140.88	158.73
E. Patient-Days/Employee	50.59	55.38	80.87	59.20	51.00	49.77
II. ON-SITE PARKING MANAGEMENT PROGRAM						
A. Spaces Controlled by Institution:						
On-site & Near-site spaces:	333	610	293	507	406	270
Remote Lot spaces:	0	0	200	475	0	0
Total:	333	610	493	982	406	270
Total Spaces/Employee:	0.39	0.23	0.43	0.65	0.41	0.19
B. On-Site Parking Charge Rates						
Per Hour:	$1.75	$0.00	$1.00	$1.00	$3.00	$0.75
Max. Per Day:	$20.00	$0.00	$7.50	$9.50	$13.00	$7.50
Monthly on-site lots:	$20.00	$0.00	None	$62.00	$95.00	$90.00
Monthly remote lots:	None	None	$40.00	$35.00	None	None
C. Reserved Spaces for Ridesharers						
Reserved Spaces:	30	0	15	182	4	20
Percent of Total Spaces:	9.01%	0.00%	3.04%	18.53%	0.99%	7.41%
Carpool Rates ($/day):	Free	Free	$15.00	Free	Free	Free
III. TDM BROKERAGE/PROMOTIONAL SERVICES						
A. Overall Marketing Program						
Information Packets (yes/no)	Yes	Yes	Yes	Yes	Yes	Yes
Special Events/Year:	1	2	2	2	1	1
B. Public Transit Promotion						
Transit Pass Sales (yes/no)	Yes	Yes	Yes	Yes	Yes	Yes
Transit Pass Subsidy/Month:	None	None	None	$4.00	None	None
C. Ridesharing Promotion						
Match List Applications (yes/no)	Yes	Yes	Yes	Yes	No	Yes
Club Bus (yes/no)	No	No	No	No	No	No
Shuttle Services (yes/no)	No	No	Yes	Extensive	Yes	Yes
D. Flextime Promotion	No	No	No	No	No	No
E. Overall Program Management						
1. Participate in JITBA (yes/no)	Yes	Yes	Yes	Yes	Yes	Yes
2. Management Coordination (y/n)	Yes	Yes	Yes	Yes	Yes	Yes
3. Liaison With City (yes/no)	Yes	Yes	Yes	Yes	Yes	Yes
4. Evaluation Completed?	Yes	Yes	Yes	Yes	No	No
5. Most Recent Survey Year:	1989	1989	1989	1990	1988	1989
6. Submit TSM Plan Per JITBA:	Yes	Yes	Yes	Yes	In Progress	No
IV. LOCAL ENVIRONMENTAL FACTORS						
A. Off-Site Parking						
Residential Parking Permits:	Yes	No	Yes	Yes	Yes	Yes
On-Street Time Limits:	2 Hrs.	No Limit	2 Hrs.	2 Hrs.	2 Hrs.	2 Hrs.
Parking Meters:	No	No	No	No	Yes	Yes
B. Transit Service						
Bus Lines within 2 blocks:	2	3	3	8	7	5
Rail Lines within 2 blocks:	1	0	0	0	0	0
Bus & Trains/Hour:	19	14	22	48	45	34
V. TDM PROGRAM SUCCESS						
A. Percent of Employees That:						
Drive Alone:	55%	59%	54%	51%	51%	43%
Share Ride:	19%	10%	14%	20%	12%	19%
Public Transit:	19%	25%	22%	24%	27%	26%
Other Modes:	7%	6%	10%	5%	10%	12%
B. Percent Employees Drive Car:	63%	63%	60%	59%	56%	51%
C. Average Auto Occupancy:	1.18	1.09	1.14	1.20	1.13	1.22

In order to avoid the potential evaluation conflicts that might arise from using multiple criteria, only two measures of TDM program success were used in this study: percent of regular, full-time, daytime employees driving alone to work; and the percent of the same employees driving a vehicle to work (whether alone or in a carpool or vanpool). The first measure (drive-alone mode split) provides a measure of the TDM program's effectiveness at shifting commuters out of drive-alone vehicles. The second measure (drive alone plus drive carpool) provides a more comprehensive measure of total TDM program effectiveness, taking into account the average automobile occupancy and the shift to nonautomobile modes (transit, bicycle, walking, etc.).

The percent of vehicle drivers (drive-alone plus carpool drivers) is obtained by adding up the drive-alone vehicles and carpooling or vanpooling vehicles, and dividing by the total regular, full-time, daytime employment at the medical institution. This measure must sometimes be estimated (in the absence of carpool occupancy data), and consequently, is not always as reliable as the percent who drive alone, which can be estimated directly from the available employee surveys.

DESCRIPTION OF INSTITUTIONS

The six medical institutions surveyed are primarily private health care providers. Only San Francisco General Hospital is a public hospital, being the provider of last resort for the City and County of San Francisco. Kaiser Hospital is a Health Maintenance Organization (HMO) providing in-patient and out-patient care to its plan members.

Davies Medical Center

Davies Medical Center is a private medical institution that consists of an acute care hospital, a skilled nursing facility, and a medical office building located 2 mi west of downtown San Francisco (*10*). Davies is licensed for 341 beds and has about 850 daytime employees. The annual patient load at Davies was equivalent to a total of 43,000 patient-days in 1988 (*11*).

Davies is located in a residential area. On-street parking is limited to 2 hr except for residents with a residential parking permit. There are no parking meters in the area.

The residential parking permit program (RPP) was implemented by the City of San Francisco between the 1986 and 1989 employee surveys at Davies. The percent of employees driving alone to Davies dropped from 63 percent in 1986 to 55 percent in 1989. In 1986, 59 percent of those employees who drove to Davies parked on city streets in the neighborhood. After implementation of the RPP, 52 percent of the employees who continued to drive their cars to Davies continued to park on the street.

A total of 333 parking spaces are provided in on-site lots. Key employees, on-site physicians, and administrators park in 149 reserved parking spaces. The remaining 184 on-site spaces are shared by nonkey employees, off-site physicians, visitors, and patients.

Visitors parking on site pay $1.50 per hour up to $20 per day if parking over 8 hr. Davies employees circumvent this penalty by pulling out of the visitors' lot during lunch and returning after lunch. Employees pay $20 a month to park. Monthly parking fees have traditionally been kept low by Davies to minimize employee parking on neighboring streets.

Davies is served by MUNI lines 24-Divisadero, 37-Corbett, and N-Judah (*12*). The N-Judah light rail line provides direct service to downtown with convenient connections to most regional transit services.

Davies provides free carpool parking, bike lockers, staggered work hours, transit information, and rideshare information. No shuttle service is provided. Davies sells transit passes on site.

San Francisco General Hospital

San Francisco General Hospital (SFGH) is a county hospital designated as the provider of last resort for the residents of San Francisco City and County (*13*). It is located 2 mi south of downtown San Francisco.

SFGH provides inpatient services, emergency services, ambulance care services, and special services. It also provides community-based outpatient service through three satellite clinics staffed by SFGH physicians.

SFGH is the teaching hospital for the University of California (UCSF). UCSF (which is located about 3 mi away) provides all professional medical staff at SFGH. UCSF staff at SFGH include 233 full-time physicians, 601 clinical faculty, 273 post-graduates, and 700 nonacademic staff.

SFGH ambulatory care services treat an average of 1,000 patients a day. SFGH is the designated trauma center for San Francisco. Its emergency department treats an average of 280 patients per day. Total occupiable floor space at SFGH is 1.2 million ft^2 in nine buildings on campus.

SFGH is licensed for 582 beds, having an average of 372 beds available. The annual patient load was equivalent to 144,000 patient-days in 1988. There are about 2,600 dayshift employees.

SFGH provides 472 marked parking spaces for its employees on site. An additional 156 vehicles park illegally on site in unmarked spaces. Visitors may park in a 112-space lot limited to 2 hr parking. There is no charge for visitor or employee parking on campus.

SFGH is located in a residential area. On-street parking in the area is free, with no time limits. There is no residential parking permit program in the neighborhoods surrounding SFGH.

SFGH is served by MUNI lines 9-San Bruno, 33-Stanyan, 48-Quintara. The No. 48 line provides bus service to the 24th Street BART station, which provides regional transit service for commuters from the Eastbay.

SFGH has an in-house TDM coordinator, sells transit passes on site, has a shuttle service to UCSF, and promotes ridesharing through distribution of matchlist applications. An additional shuttle to the BART station was started by SFGH after the October 1989 earthquake. However, this service was implemented after the employee surveys cited here.

St. Mary's Hospital and Medical Center

St. Mary's Hospital is a private medical institution with an acute care hospital and medical office building located 3 miles west of downtown San Francisco (*14,15*). St. Mary's is licensed for 531 beds, having an average 403 beds available. The annual patient load at St. Mary's was equivalent to 93,000 patient-days in 1988. St. Mary's employed about 1,150 people in 1988 (Nancy Oliva, St. Mary's Hospital, unpublished data).

St. Mary's is located in a residential area next to Golden Gate Park. On-street parking is limited to 2 hr without an L residential parking permit. On-street parking in nearby Golden Gate Park is prohibited before 9 a.m., and limited to 3 hr after 9 a.m.; however, enforcement of these restrictions is limited.

The residential parking permit program was established in the Saint Mary's area in 1987. Employee surveys in 1985 and 1989 indicated a drop in the percent of employee drive alones from 65 to 54 percent. This modal shift is probably caused in part by the implementation of a residential parking permit program.

St. Mary's provides 293 parking spaces on site and an additional 200 spaces (reserved for employees) in a remote lot ⅔ of a mile away at Kezar Stadium. Seventy-nine of the on-site spaces are reserved for physicians. The remaining 214 on-site spaces are for visitors and patients.

The St. Mary's garage charges $1.00 per hour up to $7.50 per day to the general public. The on-site visitors lot charges $2.00 per day.

Monthly parking is provided for employees only at Kezar Stadium. The monthly parking cost at Kezar Stadium is $40.00 per month. The rate is $15.00 per month for carpools at Kezar Stadium.

The following MUNI lines stop within two blocks of St. Mary's: 5-Fulton, 21-Hayes, and 33-Stanyan. Commuters from outside San Francisco must first go to downtown San Francisco and then transfer to a bus (the No. 5 or No. 21 lines) to reach St. Mary's.

St. Mary's sells transit passes on site and provides shuttle services for its employees. A subsidized free shuttle service is provided between St. Mary's and the Kezar Stadium lot.

Kaiser Hospital

Kaiser Plan Medical Center is a health maintenance organization (HMO) hospital and outpatient clinic located 2 miles

west of downtown San Francisco (*16,17*). Kaiser is licensed for 323 beds, having an average of 268 beds available. The annual patient load was equivalent to 89,000 patient-days in 1988. Kaiser recently purchased the French Hospital (located 1 mi west of Kaiser) to expand its patient handling capacity.

There are currently (1989) about 2,500 employees, up from 2,200 employees in 1986. The day shift employment is estimated at 1,500 employees (or 60 percent of the total employment) (*17*). The breakdown by employee classification is 9 percent executive, 28 percent professional or technical, 12 percent physician, 28 percent nurse, and 23 percent clerical or other. Approximately 23 percent of their employees start work between 6:01 and 7:00 a.m., 23 percent between 7:01 and 8:00 a.m., and 28 percent between 8:01 and 9:00 a.m. (*16*).

Kaiser is located next to a residential area. Commercial development is located along Geary and Masonic avenues. On-street parking is generally restricted to 2 hr without a residential parking permit. There are no parking meters on streets in the immediate area.

Kaiser is constructing a second garage and a North Wing addition, which are expected to be completed in 1991. During this period, medical center physicians, residents, surgical staff, and carpoolers have been the only employees allowed to park on site. A total of 507 parking spaces are available during construction in two small lots and one large garage. About 175 of these spaces on site are reserved for physicians. Another 200 spaces are reserved for residents. Up to 200 spaces are set aside for carpoolers.

Kaiser leases (or owns) an additional 475 parking spaces at five off-site locations. Kaiser has committed to relinquishing all off-site parking when the construction is complete.

The Kaiser garage charges 50 cents the first hour, $1.00 for each additional hour up to the $9.50 daily maximum. The monthly rate at the on-site garage is $62.00. Carpoolers park for free on-site. Off-site monthly parking costs each employee $35.00 a month.

Kaiser is served by the following MUNI lines: 24-Divisadero, 38-Geary, 38L-Geary Limited, 2-Clement, 4-Sutter, 31BX-Balboa B Express, 38BX-Geary B Express, and 43-Masonic. These lines provide frequent service to downtown San Francisco, where connections can be made to most regional transit providers. Golden Gate Transit also provides direct regional transit service to the North Bay counties.

Kaiser operates the most active TDM program among the six institutions surveyed. Kaiser recently received an award from the San Francisco Bay Area Metropolitan Transportation Commission for its TDM program.

Kaiser provides free shuttle services for employees and health plan members to downtown San Francisco, the French Hospital, and the remote parking lots. Kaiser offers free pickup service for health plan members living within 12 blocks of the medical center. Out-of-town visitors wishing to visit family members at the hospital can also request the pickup service if they are staying within 14 blocks of the center.

Monthly bus passes are sold on site, with Kaiser paying $4.00 toward the cost of each employee's pass.

Kaiser also holds several transportation fairs each year to promote alternative commute modes and publishes weekly news items in the Medical Center's Newsletter.

In 1984–1985, about 67 percent of the visitors or outpatients and 76 percent of the employees came to Kaiser in automobiles. The average automobile occupancy for employees was 1.15 persons per vehicle. The ratio of parked employee vehicles per employee was 0.66 in 1984–1985 (*18*).

St. Francis Memorial Hospital

St. Francis Hospital is located on the northwest fringe of Downtown San Francisco (*18*). St. Francis is licensed for 362 beds and has available an average of 274 beds. The annual patient load in 1988 at St. Francis was equivalent to 51,000 patient-days. St. Francis employs about 1,000 people.

The area around St. Francis is partly commercial and high-density residential. On-street parking is partly metered 1- and 2-hr zones, and partly 2-hr unmetered zones. A residential parking permit zone (2-hr parking without a permit) covers Sutter, Leavenworth, and Pine Streets.

St. Francis has 442 parking spaces in its 909 Hyde Street garage and in the medical office building garage. Employee parking costs $95 per month. Daily parking for the general public costs $13.00 per day (George Li, Pansini Corp., unpublished data).

St. Francis is served by MUNI lines 1-California, 2-Clement, 3-Jackson, 4-Sutter, 19-Polk, 27-Bryant, and the California Street Cable Car within two blocks of the hospital.

St. Francis sells transit passes on-site and provides door-to-door pick-up and drop-off services for many of its patients. However, St. Francis has not developed in-house carpool matching lists, nor prepared a program evaluation and work plan according to the JITBA guidelines.

Mount Zion Hospital

Mount Zion Hospital and Medical Center (*19*) is located two city blocks east of Kaiser Hospital. Mount Zion is licensed for 439 beds. Mt. Zion's annual patient load was equivalent to 69,682 patient-days in 1988. Mount Zion employs about 1,400 people.

The area around Mt. Zion is mostly residential with some commercial uses along the major arterials. Parking meters and posted signs limit on-street parking in the area to 1 to 2 hr. Several blocks fronting the hospital and along Divisadero have parking meters. Parking is limited to 2 hr by residential parking permit area G on nearby residential streets.

Mount Zion is served by the following MUNI lines within two blocks of the hospital: 24-Divisadero, 38-Geary, 38L-Geary Limited, 2-Clement, and 4-Sutter. These lines provide service to downtown San Francisco where connections can be made to regional transit services. Golden Gate Transit also provides service to the North Bay counties.

Mount Zion has a 120-space lot on site. Another 150 spaces are available in the medical office building garage. The garage charges 75 cents/hr up to a maximum $7.50/day. The monthly rate is $90.00.

Mount Zion provides carpool matching assistance, holds TSM fairs, and sells transit passes on site.

Mode Split Trends

The employee mode splits have varied over the years at these six institutions because of variations in environmental conditions and variations in institutional commitments to their TDM programs (see Figure 2). Fink and Twitchell (*8*) documented a significant improvement in mode splits in 1979 and 1980. These improvements occurred at the same time as a rapid increase in gasoline prices and a temporary fuel scarcity caused by the Iranian oil embargo. However, employee drive-alone mode splits continued at their improved levels through 1982, as gasoline prices stabilized. During this period, there was a continuing high level of management involvement in the TDM program.

Drive-alone mode splits then increased between 1982 and 1987 when the institutions generally slacked off in their TDM efforts (JITBA was disbanded during this period).

Since 1987, drive-alone mode splits have again returned to 1980 levels, thanks to a renewed commitment to TSM programs on the part of the institutions (JITBA was reestablished in 1987) and increasing regulation of on-street parking (through residential parking permit programs) by the city of San Francisco in the vicinity of the institutions. The renewed commitment to JITBA was spurred by city-imposed conditions on the expansion of several of these institutions. Others were motivated to rejoin JITBA through institutional peer pressure.

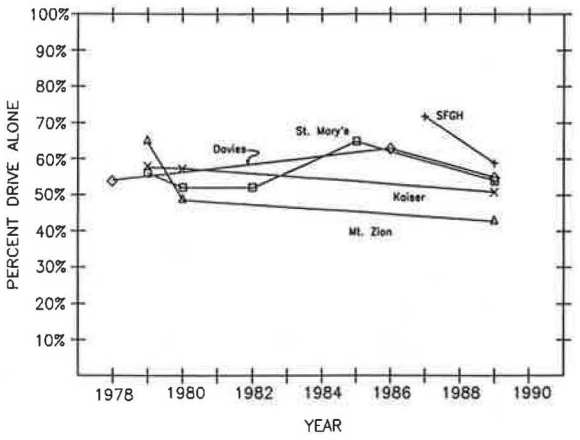

FIGURE 2 Mode split trends for San Francisco medical institutions.

RESULTS

Kaiser, St. Francis, and Mt. Zion hospitals all have generally superior mode split results (43 to 51 percent drive alone) in comparison to the other institutions (see Table 1). These three medical institutions have higher on-site monthly parking charges and more frequent public transit service than the other institutions surveyed. St. Francis and Mt. Zion are located in neighborhoods where on-street parking is regulated by parking meters. However, of these three institutions, Kaiser alone has an active in-house TDM program. The other two have relatively modest TDM brokerage services. (The yes or no answers in Table 1 do not give Kaiser full credit for the extra effort it devotes to its TDM brokerage services.)

The number of on-site parking spaces per employee, by itself, appears to have relatively little effect at these three successful institutions because they all achieve low employee automobile use with parking ratios of 0.19 to 0.65 space per employee.

The relative size of these major institutions also appears to have little effect on TDM success because these three low-automobile-use institutions range from 323 to 439 beds and from 51,000 to 89,000 patient-days per year.

Davies, SFGH, and St. Mary's have relatively higher employee automobile use. They share the common characteristics of lower on-site monthly parking charges, no on-street parking meters regulating off-site parking, and less frequent public transit service.

Again, the scarcity of on-site parking supply, by itself, appears to have little effect on employee automobile use among the poorer-performing institutions. SFGH has the lowest ratio of on-site parking spaces to employees and yet has one of the highest employee automobile uses. St. Mary's also has a relatively active TDM brokerage service and prohibits on-site employee parking; however, St. Mary's is still unable to achieve the low automobile usage of the better-performing institutions surveyed here.

There is free off-site parking with no time limits next to SFGH, which explains its high automobile use. St. Mary's employees can park in nearby Golden Gate Park to partially avoid the residential street 2-hr time limits surrounding the hospital.

Correlation Analysis

As the previous discussion has indicated, it is difficult to extract qualitatively a predominant factor or series of factors affecting TDM program success at these institutions. Consequently, a statistical correlation analysis was performed to determine which factors were most highly correlated to institutional TDM program performance.

Table 2 presents the correlation of the factors among themselves as well as their correlation with percent drive-alone and percent drive-a-car. The factors are generally listed in order of decreasing correlation with employee automobile use. Factors correlated by 50 percent or more are highlighted in bold.

Monthly on-site parking cost was found to be the most highly correlated factor to employee automobile use (with correlation coefficients of -0.85 to -0.91), followed by the off-site factors of on-street parking limits, and nearby transit service (with correlation coefficients of -0.57 to $+0.71$). (Note that TDM brokerage services were not quantifiable based on the data available from the survey and thus could not be included in this correlation analysis.)

Institutional characteristics such as employment, patient-days, and number of beds turned out to be relatively less correlated to employee automobile use (correlation coefficients of 0.19 to 0.48). These results are strongly influenced by SFGH, which tends to dominate the other institutions in these categories. However, SFGH has twice the employment and 50 percent more patient-days per year than the next larger

TABLE 2 CORRELATION MATRIX

CORRELATION MATRIX	Monthly Park Cost	On-Street Park Time	Transit Veh/hr	Parking Spaces	Patient Days	Daytime Employment	Parking/ Employee	Available Beds	Parking/ Patient	Percent Drive Al.	Percent Drive Car
Monthly Parking Cost	1.00	-0.74	0.76	-0.57	-0.27	-0.50	0.04	-0.42	0.14	-0.85	-0.91
On-Street Park Limit	-0.74	1.00	-0.61	0.86	0.24	0.91	-0.37	0.69	-0.39	0.71	0.59
Transit Veh/hr.	0.76	-0.61	1.00	-0.40	0.39	-0.35	0.59	-0.68	0.68	-0.60	-0.57
Annual Patient-Days	-0.57	0.86	-0.40	1.00	0.46	0.93	-0.22	0.78	-0.40	0.48	0.37
On-site Park Spaces	-0.27	0.24	0.39	0.46	1.00	0.37	0.72	-0.14	0.61	0.27	0.34
Daytime Employment	-0.50	0.91	-0.35	0.93	0.37	1.00	-0.37	0.66	-0.40	0.39	0.27
Park Spaces/Employ.	0.04	-0.37	0.59	-0.22	0.72	-0.37	1.00	-0.60	0.92	0.10	0.24
Available Beds	-0.42	0.69	-0.68	0.78	-0.14	0.66	-0.60	1.00	-0.82	0.38	0.19
Spaces/Patient-day	0.14	-0.39	0.68	-0.40	0.61	-0.40	0.92	-0.82	1.00	0.03	0.17
% Drive Alone	-0.85	0.71	-0.60	0.48	0.27	0.39	0.10	0.38	0.03	1.00	0.95
% Drive Car	-0.91	0.59	-0.57	0.37	0.34	0.27	0.24	0.19	0.17	0.95	1.00

Note: Correlation of explanatory factors to each other and to employee mode split (Plus or minus 1.00 indicate a high degree of correlation. Zero indicates no correlation.)

institution in the survey; the number of licensed beds at SFGH is within 10 percent of the next larger institution.

On-site parking supply characteristics are poorly correlated (0.03 to 0.34) to employee automobile use at each institution. This is probably because of the availability of on-street parking at all institutions. Unfortunately, employees can and do use visitor parking facilities at many of the institutions, so it was not possible to develop separate data on employee parking spaces per employee.

Predicting TDM Effectiveness

The correlation analysis results were used to identify the most promising factors for inclusion in a linear equation for predicting employee drive-alone and drive-car mode splits. The on-site parking cost was identified in the correlation analysis as the single most significant factor influencing employee automobile use at these medical institutions. Linear regression analysis was used to construct equations for predicting employee mode splits given this factor, as follows:

$$\text{Percent who drive alone} = 0.581 - 0.0012\ (\text{monthly parking cost in dollars})$$

For this relationship, $R^2 = 0.72$, standard error of estimate = 0.047, standard error of parking cost coefficient = 0.0004, and the 95 percent confidence interval for cost coefficient = −0.0021 to −0.0003.

$$\text{Percent who drive car} = 0.596 - 0.0011\ (\text{monthly parking cost in dollars})$$

For this relationship, R^2 = 83 percent, standard error of estimate = 0.046, standard error of parking cost coefficient = 0.0003, and the 95 percent confidence interval for cost coefficient = −0.0017 to −0.0005.

Figure 3 shows the predictions of a drive-car mode split using the latter equation versus the observed mode splits at these institutions. These predictions, solely on the basis of monthly parking cost, are within 1 percent of actual for all but two of the institutions. Automobile use by employees at St. Francis is noticeably higher (3 to 4 percent) than predicted, whereas automobile use at Mt. Zion is significantly lower (3 to 4 percent) than expected on the basis of monthly parking cost alone.

The addition of on-site parking supply measures (total spaces, spaces per employee, etc.) to the above regression equations did not significantly improve the fit of the regression line, and resulted in coefficients for these variables not significantly different from zero.

The combination of the other two most significant factors (transit service and on-street parking limits) with parking cost in the equation also resulted in only modest improvements to the explanatory power of the equations. This is primarily because the on-site parking charges are so highly correlated to on-street parking supply and coincidentally to the frequency of transit service (see Table 2). Davies Medical Center has stated that it purposely sets its parking rates low to avoid employee overflow onto residential neighborhoods. Indeed, institutions often set their parking rates according to the prevailing parking charge rates in their vicinity.

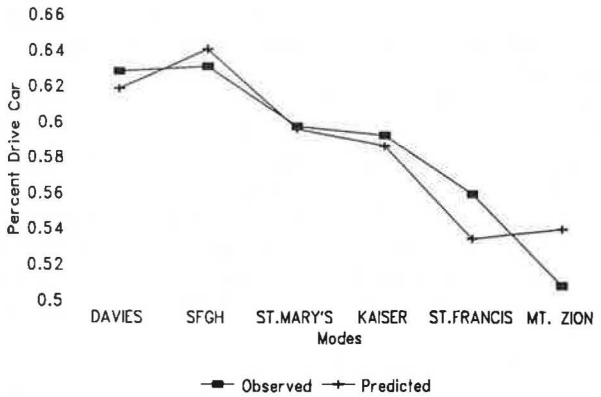

FIGURE 3 Predicted versus actual drive-car mode splits.

The other factors of total employment, annual patient-days and available beds, also did not significantly improve the explanatory powers of the equations and resulted in illogical coefficients for the variables, or coefficients not significantly different from zero.

The number of parking spaces reserved by each institution for carpoolers was not included in the analysis because institutions adjust this number to roughly match demand. Thus the number of carpool spaces could not be used as an explanatory variable for employee mode split.

CONCLUSIONS

The analysis has demonstrated that on-site parking charge rates, off-site parking restrictions, and frequent transit service are major factors in successful TDM programs at the major medical institutions in San Francisco. On-site parking supply turned out to be a less critical factor, primarily because of the availability of abundant free parking on nearby city streets at these institutions.

Because of the high degree of correlation between the parking charge rates, off-site parking restrictions, and transit service, it was possible to build a satisfactory predictive equation for employee mode split solely on the basis of the on-site parking charge rate. This equation indicated that the employee drive-alone mode split could be reduced by one percentage point for every $8.00 increase in monthly parking charges at these major medical institutions. (The 95 percent confidence interval for this result is between $5.00 and $33.00 per month.)

The analysis also indicated that on-site parking charges are currently highly correlated with off-site parking restrictions and transit service improvements. Consequently, to obtain the reductions in employee automobile use cited, it would be necessary to coordinate the parking charge increases with increased off-site parking restrictions and improved transit service.

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