CIRRELT

Centre interuniversitaire de recherche
sur les réseaux d'entreprise, la logistique et le transport

Interuniversity Research Centre
on Enterprise Networks, Logistics and Transportation

Quality of Service in Dial-a-Ride Operations

Julie Paquette
Jean-François Cordeau
Gilbert Laporte

September 2007

CIRRELT-2007-32

Bureaux de Montréal :
Université de Montréal
C.P. 6128, succ. Centre-ville
Montréal (Québec)
Canada H3C 3J7
Téléphone : 514 343-7575
Télécopie : 514 343-7121

Bureaux de Québec :
Université Laval
Pavillon Palasis-Prince, local 2642
Québec (Québec)
Canada G1K 7P4
Téléphone : 418 656-2073
Télécopie : 418 656-2624

www.cirrelt.ca

Quality of Service in Dial-a-Ride Operations

Julie Paquette[1], Jean-François Cordeau[1,*], Gilbert Laporte[1]

[1] Interuniversity Research Centre on Enterprise Networks, Logistics and Transportation (CIRRELT), Université de Montréal, C.P. 6128, succursale Centre-ville, Montréal, Canada H3C 3J7 and HEC Montréal, 3000 Côte-Sainte-Catherine, Montréal, Canada H3T 2A7

Abstract. Few studies have been conducted on the quality of service provided by the organizations responsible of providing dial-a-ride services for people with reduced mobility. In order to study quality in such contexts, the paper first defines what is meant by "quality" in the service sector. The difference between quality and satisfaction is then discussed, and the most well-known scales of measurement are introduced. After a brief review of the techniques and tools used in the service sector to improve quality, the notion of quality in dial-a-ride services is discussed more in depth. In particular, the dimensions and attributes of various scales of measurement used by researchers in dial-a-ride studies are reviewed. Finally, the impact on quality of various elements, like the size and type of organization and the operational rules used, are discussed.

Keywords. Dial-a-ride services, adapted transportation, quality of service.

Acknowledgements. This work was supported by the Social Sciences and Humanities Research Council of Canada and by the Natural Sciences and Engineering Research Council of Canada (NSERC) under grants 227837-04 and 39682-05. This support is gratefully acknowledged.

---

* Corresponding author: jean-francois.cordeau@hec.ca

Dépôt légal – Bibliothèque nationale du Québec,
Bibliothèque nationale du Canada, 2007

1 Introduction

Dial-a-ride services are provided for people with reduced mobility, typically the elderly and the handicapped. According to Cordeau et al. (2007a), due to "the ageing of the population and the trend toward the development of ambulatory health care services, more and more people rely on door-to-door transportation systems" to move from one place to another. Many major cities around the world provide dial-a-ride services to their citizens: London, Paris, Berlin (Borndörfer et al., 1997), Bologna (Toth and Vigo, 1997), Copenhagen (Madsen et al., 1995), Hong Kong, Helsinki, Stockholm, Toronto, Montreal, Sao Paulo, Los Angeles, New York are some of the cities in which dial-a-ride services are the most advanced. In addition to these, several embryonic or partial services exist in several parts of the world. For example, Rickert et al. (2004) report that "in recent years, major cities in Latin America have begun to initiate accessible transport", but these services do not always qualify as full dial-a-ride services. Maunder et al. (2004) have reported on experiments carried out in India, Malawi and South Africa, where basic improvements to public transportation were made to accommodate people with disabilities. Dial-a-ride services are one possible strategy to enhance the mobility of handicapped and elderly people, but such services are costly and thus cannot be implemented everywhere (Venter et al., 2004).

Dial-a-ride systems may function very differently from one place to the next. Generally, users of dial-a-ride services must phone a call center to reserve a trip. This booking can be made in advance for trips occurring several times a week (regular service), for a trip on demand (occasional service) or even for a spontaneous trip with a departure in a few hours (occasional dynamic service). A request for transportation including several types of information is created in the transporter's system. First, users must provide the address of the pickup and destination locations, which are, in most cases, different for each user. For the outbound trip, users must provide the time at which they wish to arrive at their destination. However, for the inbound trip they usually specify their desired pickup time. In addition, users must indicate whether or not they will be accompanied by an attendant and whether they will be using a wheelchair. These last details are necessary because a passenger with an attendant does not take up the same amount of space as a passenger traveling alone, and not all vehicles can carry wheelchairs.

Dial-a-ride problems are part of the more general transportation-on-demand (TOD) problems (Cordeau et al., 2007a), which consist of determining routes and schedules for vehicles that transport users on demand from a pickup point to a destination (e.g., air taxis). These problems are also part of the family of vehicle routing problems, which have been thoroughly studied over the past 50 years (Cordeau et al., 2007b). For a comprehensive review of the literature on dial-a-ride problems, the interested reader is referred to Cordeau and Laporte (2007) and Berbeglia et al. (2007). Most dial-a-ride

studies focus on reducing operational costs. According to Armstrong and Garfinkel (1982), improving routing efficiency, even slightly, can have a significant impact on the cost of public and private transportation services.

Nonetheless, because adapted transportation services are intended for people, and not merchandise, quality of service is an important factor. In many countries, governments require providers of dial-a-ride services to ensure a quality of service equal to that of regular public transit. Compared to the number of papers reporting on the development of DARP algorithms, relatively few studies have been carried out on the service quality provided by dial-a-ride service providers. Our aim is to provide a comparative overview of quality in dial-a-ride services. As the first step towards this goal, in Section 2, we define what is meant by "quality" in the service sector. The difference between quality and satisfaction is then discussed. These clarifications allow us to discuss SERVQUAL, the best known scale of measurement for service quality. A quick review of techniques and tools used in the service sector to improve quality then follows. In Section 3, quality in dial-a-ride services is discussed more in depth, and the dimensions and attributes of various scales of measurement used by researchers in dial-a-ride studies are reviewed. This review includes studies in which quality is defined by customer perceptions, and those in which quality is defined by transporters specifications. Finally, the impact on quality of various elements, like the size and type of organization and the operational rules used, is discussed. Section 4 offers our conclusions.

2 Quality in the service sector

The service sector is a relatively new subject of study in the literature. A number of researchers have attempted to determine the particularities of the service sector compared to the product sector, and to develop definitions, theories and techniques appropriate to this sector. Others are more interested in showing that the theories, definitions and techniques available for the product sector also apply to the service sector. In this section, we will report on these two research trends. First, several definitions of quality are provided. Then, the difference between the constructs of satisfaction and quality is explained. Finally, various measurement scales are presented, and some techniques and tools for improving quality are discussed.

2.1 Defining quality

There appears to be no universally accepted definition of the construct of "quality". In their article, Reeves and Bednar (1994) compare several of the most common definitions, each of which is relevant to a particular context. According to Schneider

and White (2004), there are three approaches to defining quality: a philosophical approach, a technical approach, and a customer-based approach. The philosophical approach defines quality as a synonym for excellence. From this point of view, quality cannot be known in advance; it can simply be recognized when it is perceived. Therefore, this definition cannot be given more in detail, nor can quality thus defined be measured. The technical approach considers quality from a more objective, absolute perspective. This approach judges quality in terms of conformity to specifications and "zero-default-tolerance" policies, and is applied mainly in the context of standardized mass production. In the customer-based approach, the definition of quality depends on individual perceptions and is therefore rather subjective. This definition is often used in the service sector because perceptions tend to be intangible and thus sometimes difficult to measure. We will limit our discussion to the definitions of technical quality and customer-based quality.

Since dial-a-ride services use tangible elements (e.g., vehicles), and since some of the elements connected to the service performance are measurable (e.g., time), it is possible to include certain aspects of quality in service specifications. However, according to Schneider and White (2004), narrowing the goals to include only measurable criteria can limit the mind-set of employees, who may thus tend to ignore the dimensions of quality that cannot be measured. Thus, a customer-based definition of quality can be adopted to complement the technical definition. Clearly, given that dial-a-ride services involve many interactions with customers, these customers and their perceptions of the service are very important. With this in mind, Zeithaml and Parasuraman (2004) have noted that service quality can be defined as "the difference between customer's expectations of service, and their perceptions of the actual service performance"(p.XI).

In addition to this categorization of quality types, it is also possible to differentiate between two types of quality management practices: internal and external. According to Gummesson (1992), internal quality management refers to process management and to the dimensions of quality that can be controlled by the company, whereas external quality management is a question of understanding customer needs in order to provide the corresponding service. A parallel can be made between the definitions of Schneider and White (2004) and the two types of management practices. Internal quality management is closely related to the technical definition of quality because the specifications can be controlled by the company, whereas external quality management practices are closely related to the customer-based definition of quality because they are based on customer needs and perceptions.

Finally, there exist many ways to define quality, and another way to define this construct in the service sector is the one developed by Grönross (1984). In his work, Grönross distinguishes between only two types of quality: technical quality and functional quality. Technical quality corresponds to "what the consumer receives as a result of his interaction with a service firm"(p.38). For example, in dial-a-ride services, the

result of the interaction between the user and the transportation service is the customer's trip from the pickup point to the destination. However, in the service sector, customers are not only interested in the result of the production process (the trip) but also in the process itself (the service experience). This is what Grönross calls functional quality. In dial-a-ride services, the service experience is connected to several elements, including the friendliness of the driver, the punctuality of the vehicle, and the type of reservation method, with a preference for one that is flexible and easy to use. Grönross underlines that technical quality is necessary for customer satisfaction but is not sufficient to ensure customer satisfaction; functional quality also plays a role in satisfaction. He thus emphasizes that both types of quality must be evaluated to determine whether or not a quality service has been provided.

2.2 Differentiating between quality and satisfaction

The difference between quality and customer satisfaction is subject to debate. There appears to be four ways to differentiate between the two constructs. First, Rust and Oliver (1994) distinguish between quality and satisfaction based on the number of factors taken into account by customers when evaluating the service. These authors believe that when evaluating quality, customers consider only the specific factors under a company's control; however, they feel that customer evaluations of satisfaction are much wider and take into account many factors that are not necessarily under the company's control. For example, a customer may consider a trip to be of "good quality" if it takes place under acceptable conditions and the driver is friendly, but the same customer might be dissatisfied with the same trip if the vehicle is caught in traffic and he or she feels anxious about arriving late at his or her destination. Thus traffic — which cannot be controlled by the transportation company — has an impact on customer satisfaction but not on the customer's perception of service quality, given that the customer arrives at the destination on time.

A second way to distinguish between the two constructs lies in the fact that, although quality can be evaluated even if customers have not yet tried the service, satisfaction can only be assessed after the service has been used, because customer satisfaction depends on an affective reaction to the individual experience (Bitner and Hubbert, 1994; Rust and Oliver, 1994; Storbacka et al., 1994; Oliver, 1997). For example, friends and family of service users can assert that the quality of the service is good based only on what they have heard about the service, without ever having used it. But, to make a statement about their satisfaction, they would need to have used the service themselves.

A third way to distinguish between quality and satisfaction has been discussed by Parasuraman et al. (1988), Rust and Oliver (1994) and Schneider and White (2004).

When customers evaluate quality, they compare their perceptions of the service (i.e., what the service really is) with their expectations of service excellence (i.e., what the service should be), but when they evaluate satisfaction, they compare their perceptions with their predicted expectations (i.e., what they thought the service would be). For example, for a dial-a-ride service, a customer could state that, if the vehicle arrives at the destination within a five-minute time window — which is ideal in his or her opinion — then this would be a very good level of service quality. If the vehicle arrives within this time window, the customer will consider the service to be of good quality; however, if the customer arrives late at the destination point, he will consider the service to be of poor quality. On the other hand, if the customer, based on past experience, expects the vehicle to arrive within a fifteen-minute time window, and the vehicle arrives on time, the customer will be very satisfied. Ultimately, a fourth way to distinguish between the two constructs is emphasized by Rust and Oliver (1994), Storbacka et al. (1994) and Oliver (1997). They assess that evaluations of quality depend on a cognitive judgement of the service, while satisfaction depends on a judgement that is both cognitive and affective.

The relationship between quality and satisfaction has also been a subject of debate among researchers over the past few years. According to Cronin and Taylor (1992), "quality is antecedent to customer satisfaction"(p.55). Bitner and Hubbert (1994) add that satisfaction has an indirect impact on quality and conclude that quality and satisfaction are independent, but correlated constructs. Schneider and White (2004) concur by stating that "there does appear to be consensus that the two are conceptually distinct yet empirically overlapping"(p.51).

2.3 Measuring quality

The most well-known scale of measurement for service quality is SERVQUAL, developed by Parasuraman et al. (1988). This scale relies mostly on the external service quality dimensions suggested by Gummesson (1992). To develop this measurement scale, Parasuraman et al. (1985) first conducted exploratory research to better grasp the concept of quality in service companies. This exploratory research was based on interviews with managers and on discussions with twelve groups of clients from four different types of services: banks, credit card companies, security brokerages, and repair and maintenance firms. From this study, ten dimensions of quality were identified. These dimensions were re-examined and refined during the SERVQUAL development period through an iterative process using the alpha coefficient, among others. The resulting questionnaire includes the five dimensions presented in Table 1. Reliability appears to be the most critical dimension for clients, whereas tangibility is the least important. Zeithaml and Parasuraman (2004) report that SERVQUAL has been used successfully to measure service quality in public and private companies in several dif-

ferent contexts, cultures and countries.

Dimensions	**Concise definitions**
Tangibles	Physical facilities, equipment and appearance of personnel
Reliability	Ability to perform the promised service dependably and accurately
Responsiveness	Willingness to help customers and provide prompt service
Assurance	Knowledge and courtesy of employees and their ability to inspire trust and confidence
Empathy	Caring, individualized attention the firm provides its customers

Table 1: Dimensions used in SERVQUAL (Parasuraman et al., 1988)

Several researchers have criticized the SERVQUAL, which led its designers to modify slightly their measurement scale. The three principal criticisms, and the responses of Parasuraman et al., have been presented succinctly in a book by Zeithaml and Parasuraman (2004). First, SERVQUAL is based on the difference between customer expectations and their perceptions of the actual service. Several authors have suggested basing the analyzes on perceptions only, thus excluding expectations. According to Cronin and Taylor (1992), a measurement scale consisting uniquely of customer perceptions would avoid the measurement bias introduced by the simultaneous evaluation of both expectations and perceptions. In addition, this measurement scale would have a better discriminating validity and would be more concise since it would include fewer items. However, as explained in their 1994 article, Parasuraman et al. believe that measuring expectations is of greater value for the diagnosis. They feel that if only perceptions are considered, managers will give priority to improvements concerning the items with the lowest quality coefficients, leaving items with a high quality coefficient, but which are still quite far from client expectations, unimproved. Thus, in their opinion, only taking perceptions into consideration could fool the managers, who will not necessarily assign the right priorities to their actions.

Second, certain researchers have questioned how the concept of expectation could be operationalized. Clearly, several definitions of this concept exist, which does not facilitate its operationalization. For this reason, Parasuraman et al. have modified SERVQUAL to include a section on desired services (i.e., those that should be offered), one on the minimum acceptable service, and one on the perceptions of the actual service. These modifications allow the actual service to be situated with respect to the minimum required service and to a service of excellent quality.

Third, some critics have asserted that measuring the difference between perceptions and expectations directly is, from a psychometric point of view, better than measuring this difference indirectly. However, no empirical study has yet proved this assertion. Thus, SERVQUAL, which provided the first step in the study on quality in service companies, remains a frequently used tool today. In fact, the various criticisms in the years since its conception have allowed its authors to improve their tool.

Several researchers in the quality domain have also wondered whether it is a good idea to develop a common measurement tool, like SERVQUAL, for all services, or whether it would be better to develop specific measurement scales for each sector. Rust et al. (1996) have recommended that discussion groups be organized to ensure that no important aspects of service quality are left out of the tool's questionnaire, and that the terminology used in the questionnaire is the same as the one used by the customers. Schneider and White (2004) have suggested that a process similar to the one used by Parasuraman et al. be used to determine whether or not a measurement scale is appropriate for the context to be studied. If these recommendations and suggestions were to be followed, researchers could begin with small discussion groups to identify the elements of quality specific to the service studied. Then, they could add these elements to those already in SERVQUAL, and analyze the results using statistical techniques. Certainly, SERVQUAL is a good starting point for researchers wanting to study quality in the service sector, but as several authors have suggested, before using SERVQUAL, a preliminary study should be carried out to determine whether or not SERVQUAL should be adjusted for the study context.

Other authors have also developed lists of dimensions and attributes similar to those described by Parasuraman et al., but these lists also have their differences and specificities. Grönross (1990) has synthesized several studies on the dimensions of quality in the service sector. The six dimensions thus highlighted include several that are inspired by Parasuraman et al., as well as one called "service recovery", taken from Albrecht and Zemke's study (1985) for British Airways. In Grönross's opinion, in addition to being appropriate to the airline sector, this last dimension could also be relevant for other service providers. Remarking that information technology (IT) had become increasingly prevalent in the service sector, sometimes even replacing customer contact personnel, Gummesson (1992) emphasized the contribution of IT, grouping the dimensions and attributes that he found in the literature about quality into three subsets: service elements, tangible elements and IT software elements.

2.4 Improving quality

Over the last century, researchers and operations managers have developed several techniques and tools for improving quality. These are primarily applicable in the manufacturing sector (i.e., companies producing tangible products) since, in the past, the economy was traditionally based on that sector. However, over the last few decades, the service sector has gained in importance. Many researchers believe that some of the techniques and tools developed for the manufacturing sector can also be used in the service sector: for example, "blueprinting" (Shostack, 1992), activity-based management and integrated "scorecards" (Van Looy et al., 1998), and the Quality Function Deployment (QFD)/House of Quality (HofQ) (Hauser and Clausing, 1988).

In the HofQ, a matrix is used to link the first two components — customer requirements and the weights assigned to them — to the second two — internal standards and specifications. These four components constitute the walls of the HofQ. The relationships between requirements and specifications are indicated by a symbol in the matrix where the two categories intersect. This symbol may vary depending on the strength of the relationship (e.g., a "$\surd$" for a strong positive relationship and an "X" for a relatively negative relationship). The roof of the HofQ is composed of the relationships that exist between the different specifications, allowing a manager to rapidly identify the trade-offs that will need to be analyzed. The HofQ foundation is grounded in the belief that the products or services should reflect customer desires and expectations. This means that several company functions (e.g., marketing, operations and design engineering) must work together from the moment of conception of the product or service so that the product specifications will meet the needs and expectations of the customers. Gummesson (1992) considers that "the external, customer-oriented dimensions of quality [expectations] have to be matched with internal, management-oriented dimensions [specifications] in order to produce quality services"(p.177). Thus, he affirms that quality is a factor that helps to integrate internal operational orientations with the more external marketing orientations. Internal and external quality management practices are thus said to be interdependent. According to Hauser and Clausing (1988), "the HofQ is a kind of conceptual map that provides the means for interfunctional planning and communications"(p.63).

The HofQ tool was adapted by Stuart and Tax (1996) for the service sector. These authors see this tool as integrating a company's operations, human resource management, IT and marketing functions, which they feel is necessary in the service sector. In fact, they believe, like Booms and Bitner (1981), that service quality encompasses the physical service environment, the exchanges between customers and the personnel in contact with those customers, and the process that facilitate the delivery of the service, all of which require that several company functions operate simultaneously. These researchers indicated their surprise at the tool's low rate of use in the service sector since they felt that it was perfectly adapted to the challenges of designing, or redesigning, services.

The HofQ was used by Curry and Herbert (1998) to study quality improvements in three public services. These researchers also used the measurement scale developed by Parasuraman et al. (1988) to gather the opinions of the users (customers) of these services. The quality coefficients obtained with this scale for the various attributes can be used to weight the importance assigned by customers to the requirements in the HofQ. Thus, the QFD/HofQ tool highlights the links between the customer requirements and the company's internal standards and specifications. These authors do not, however, discuss how to proceed when the attributes are difficult to quantify (e.g., the politeness and friendliness of a driver).

Gap type	Theoretical constructs
Customer expectations versus manager perceptions	Marketing research orientation Upward communication Levels of management
Management perception versus service quality specification	Management commitment to service quality Goal-setting Task standardisation Perception of feasibility
Service quality specifications versus service delivery	Teamwork Employee-job fit Technology-job fit Perceived control Supervisory control systems Role conflict Role ambiguity
Service delivery versus external communications	Horizontal communication Propensity to overpromise

Table 2: Four gaps model of Parasuraman et al. (1985) and Zeithaml et al. (1988)

Unlike the techniques and tools just described, the model developed by Parasuraman et al. (1985) and Zeithaml et al. (1988) is not based on the manufacturing sector, but was specifically developed to improve quality in the service sector. As Zeithaml and Parasuraman (2004) observe, quality improvements can be described in terms of reducing the gap between customer expectations and perceptions of the actual service. In their model, Parasuraman et al. identify four types of gaps: 1) the gap between customer expectations and manager perceptions of these expectations, 2) the gap between manager perceptions of customer expectations and the service quality specifications, 3) the gap between service quality specifications and the service actually provided, and 4) the gap between the service provided and the one that is communicated to customers of the service. Thus, a manager who wants to improve the quality of the service can undertake actions that target these sources of influence. Table 2 summarizes the theoretical constructs behind each of the four gap types.

3 Quality in dial-a-ride services

As mentioned in Section 2.1, quality can be defined according to company specifications (internal) or according to customer perceptions (external). In the transportation sector, internal quality is more connected to operations research (OR) and operations management research, while external quality is more connected to marketing and service operations management research. To our knowledge, very few studies have been conducted on external quality in the dial-a-ride sector. On the other hand, the op-

erations research literature on the subject of internal quality in dial-a-ride problem is quite extensive, even though the same specifications are almost always used in order to facilitate a more direct comparison of the algorithms.

3.1 Measuring quality

The following review differentiates between the studies using the definition of quality based on customer perceptions (customer-based quality, external management practices) and the studies using the definition based on specifications (technical quality, internal management practices).

3.1.1 Quality as defined by customer perceptions

In 1986, McKnight cited Falcocchio (1979) as one of the first researchers to have mentioned, at least indirectly, certain dimensions and attributes that could explain and define quality in dial-a-ride services. Falcocchio developed different weighting systems for six user subgroups, which he then used to evaluate dial-a-ride systems. Table 3 shows the three dimensions — convenience, comfort and safety — under which the eleven attributes used in his study are distributed.

Dimensions	**Attributes**
Convenience	Reliability Waiting time Transfers Ease of entry and exit Walking distance
Comfort	Heating and ventilation Noise Sudden stops and turns Having a seat
Safety	Fear of falling Fear of muggings

Table 3: Dimensions used by Falcocchio (1979)

In addition to this study, a number of authors feel that the dimensions and attributes of quality in public transportation in general also apply to dial-a-ride services. For example, Pagano and McKnight (1983) developed a quality index for dial-a-ride services based on a list of attributes originally established for public transportation, on a survey of the dial-a-ride literature, and on their own observations. This list, composed of 64 attributes, was then sent to a panel of experts to make sure that no important attributes were left out. After this preliminary step, 41 attributes were retained and classified

according to eight service quality dimensions, as shown in Table 4. As can be seen from the table, Pagano and McKnight (1983) reused several of the attributes used by Falcocchio. This study was also reported in McKnight et al. (1986).

To assess the importance of each of the dimensions and attributes, Pagano and McKnight (1983) developed a questionnaire and sent it by post to 659 dial-a-ride users. The researchers excluded the blind, the deaf and the mentally handicapped from their sample, which may have created a bias in terms of the representativity since these user categories represent a non-neglible fraction of the dial-a-ride service customer base. The response rate for the questionnaire was 34.6%, which is acceptable for a questionnaire sent by post. For their analyses, the researchers divided the users into four groups: semi-ambulatory people under 65 years of age, semi-ambulatory people over 65 years of age, wheelchair users under 65 years of age, and wheelchair users over 65 years of age.

The conclusions of Pagano and McKnight (1983) underline that the most important dimensions are not the same for the two groups under 65 as for the two groups over 65. In fact, reliability is the most important dimension for those under 65, while safety is most important for those over 65. In addition, depending on the dimensions, the most important attributes are not always the same for the different user groups. The researchers list the 15 most important attributes, shown in bold in Table 4, all dimensions and user groups included. They conclude that providing a quality dial-a-ride service is complex, since the quality of the service depends on several attributes and the different user groups do not always use the same quality criteria.

Denson (2000) also uses some of the dimensions and attributes compiled by Pagano and McKnight (1983) to guide the development of qualitative indicators for evaluating the quality of a Delaware dial-a-ride service from an external perspective. She uses the terms “satisfaction” and “service quality” interchangeably. She mentions that, to ensure that the regulations of the “Americans with Disabilities Act” are respected, dial-a-ride service providers must develop standards. She cites Glauthier and Ellis (1993), who reported on the standards used by a service provider in California (shown in Table 5). According to Denson, it is important for a dial-a-ride company to decide if it wants to meet customer expectations (external quality) or if it only needs to meet the legal requirements (internal quality). For this reason, in a preliminary step, she combined the quality attributes in a questionnaire administered by telephone to 2500 users of dial-a-ride services. A response rate of 50% allowed her to draw statistically significant conclusions about the quality of service perceived by users. As was mentioned earlier for another study, the representativity of the sample population in this study cannot be guaranteed, despite the reasonable size of the sample.

The above study distinguished between factors of user satisfaction and dissatisfaction and analyzed the data according to the characteristics of the different groups within

Dimensions	Attributes
Reliability	**(1) Notification of delays or cancellation of service** (2) Wait time for pickup at home (3) Wait time for pickup away from home **(4) Arriving at destination on time** (5) Few delays while on the vehicle
Comfort	**(6) Guaranteed seat or location for wheelchair** (7) Condition and cleanliness of the vehicle (8) Smoothness of the ride (9) Air conditioning and good ventilation (10) Sheltered waiting areas for pickups away from home (11) Seats at waiting areas for pickups away from home
Convenience of making reservations	(12) Accommodation to changes in reservations **(13) Being picked up at time selected by traveller** **(14) Shortness of reservation time** (15) Convenience of return reservation procedure
Extent of service	**(16) Total number of hours of service** **(17) No or few restrictions on where vehicle will go** (18) Service on evenings (19) Service on weekends (20) Low rate of turning down reservations
Vehicle access	(21) Width of aisle **(22) Height of first step** (23) Number of steps (24) Presence of wheelchair lift or ramp (25) Assistance in getting from vehicle to destination (26) Assistance in carrying packages **(27) Short distance from house or destination to vehicle**
Safety	(28) Low probability of personal assault (29) Low probability of falling **(30) Type of tie down** (31) Position of the wheelchair in the vehicle **(32) Low probability of a traffic accident**
Driver characteristics	(33) Ability to handle medical emergencies **(34) Courtesy and friendliness** **(35) Knowledge of general needs** (36) Familiarity with habits and needs of individual user (37) Neatness and professionalism
Responsiveness	**(38) Courtesy and friendliness of telephone operators** **(39) Ease of getting clear information on service** (40) Receptiveness to complaints and user suggestions (41) Procedure for follow-up on complaints

Table 4: Dimensions and attributes used by Pagano and McKnight (1983)

Attributes	**Service standards**
Pickup time	15 minute pickup window
Trip denials	No more than 5% of all requests
Missed trips	No more than 2% of all promised trips
Ride time length	Shall not exceed 60 minutes for more than 5% of the trips

Table 5: Californian provider's service standards cited by Denson (2000)

the sample. In fact, for this State of Delaware dial-a-ride service, which groups the services of three of the state's counties together, both the youngest users and the most handicapped are less satisfied than other groups. In addition, despite the fact that their county is the only one that conforms strictly to the law, the respondents from the largest of the three counties have a lower satisfaction rate for almost all the attributes compared to those from the other two counties. This observation highlights the disparity between the internal definition of quality and the external one used by users.

The above studies were all carried out in the USA. The following study by Knutsson (1999), which aims to use quality attributes to estimate the demand for dial-a-ride services, was conducted in Sweden. Knutsson used, among others, the quality index developed by McKnight et al. (1986) to develop his postal questionnaire. The complete list of the five dimensions (i.e., information, dignity, comfort, trip time and price) and their breakdown in 40 attributes is given in Table 6. Several of the attributes used by Knutsson are inspired by those used by Pagano and McKnight, but they are not necessarily classified in the same dimension. The last column of Table 6 indicates the number of the Pagano and McKnight attribute that most closely resembles the Knutsson attribute. A response rate of 65% allowed Knutsson to highlight the six quality attributes that were the most important for users. These attributes, showed in bold in Table 6, form the basis of a utility function that is part of a Logit model. Knutsson concludes that there are two groups of users with different characteristics in the Stockholm County: one group that is ready to pay to obtain a specialized service (women who travel a lot and who have a fairly high salary), and one group that is not ready to pay for such specialized service (men who do not travel much, have low revenues, are not confined to wheelchairs, or are either unemployed or students).

From all of these studies on quality as defined by user perceptions, it appears that the most important dimensions and attributes are not the same for various groups of users. In addition, it seems that different user groups do not have the same level of satisfaction with respect to the different service attributes.

Dimensions	**Attributes**	Corresponding attribute in Pagano and McKnight
Information	Information access	
	Understandable information	
	Faultless and complete information	
	Unambiguous information	
Dignity	Being taken seriously as a traveller	
	Confidence with respect to what to do and where to go	
	Personal privacy	
	Reliability of service	
	Safety day and night time	
	Medical emergency capability	(33)
	Suitable and motivated driver	
	Courtesy and friendliness	(34)
	Familiarity with personal needs	(36)
Comfort	Service on weekdays	(18)
	Service on weekend	(19)
	Punctuality, departure	
	Punctuality, arrival	(4)
	Freedom of crowding	
	Booking	
	Follow-up to complaints	(41)
	Few restrictions	(17)
	Prebooking of return	(15)
	Smoothness of ride	(8)
	Vehicle inside design	
	Number of steps	(23)
	Space and seating	(6)
	Lift (or ramp)	(24)
	Distance to vehicle	(27)
	Driver assistance	(25)
	Ease of complaining	(40)
	Possibility to choose departure time	(13)
Travel time	**Reasonable in-vehicle time**	(5)
	Waiting time away from home	(3)
	Waiting time in the telephone switchboard	
	Total trip time	
	Delays on vehicle	
	Prebooking time	(14)
	Punctuality, pickup time	
Fare	Worth its price compared to public transport	
	Fare	

Table 6: Dimensions and attributes used by Knutsson (1999) (Source: Knutsson, S. (1999). Valuing rider quality attributes in the Swedish special transport services. In Urban Transport Systems, 2nd KFB-Research Conference. Lund, Sweden: Lund University, Department of Technology and Society LTH, Appendix 1)

3.1.2 Quality as defined by specifications

In addition to marketing surveys, several operations research and operations management studies were conducted to automate the vehicle dispatching and to determine the trip schedules for the dial-a-ride problem. Several OR researchers mention that the distinctiveness of the dial-a-ride problem is that people rather than merchandise are transported and thus service quality (e.g., during the trip) must be taken into account. Thus, transportation systems often include specifications about service quality. Most of the time, these specifications are part of the constraints appearing in the vehicle routing models. Table 7 presents the different ways in which quality is expressed in OR models and the authors that have used them.

Specifications are the measurements of the attributes that are the most easily quantifiable and that have a direct relationship with the vehicle dispatching and the trip schedules. For example, the most frequent attributes are time windows, deviations from the desired or promised time at the point of origin or destination, maximum trip time, deviation between the trip time and the direct travel time, total trip time, and wait time.

A relevant parallel exists between these specifications and the attributes listed by researchers working on quality as defined by customer perceptions. In fact, item (4) "arriving at destination on time", item (2) "wait time for pickup at home", and item (3) "wait time for pickup away from home" are directly connected to time windows or to deviations from the requested time. Similarly, item (5) "few delays while on vehicle" is connected to minimizing the deviation between the trip time and the direct travel time and to the wait time during trips. In the OR literature, the standards most frequently used are 15 minutes for the time windows and 90 minutes for the maximum trip time.

The specifications used to represent quality in dial-a-ride problems quantify the attributes that appear in the 1983 Pagano and McKnight list of quality attributes based on customer perceptions. The specifications found in the operations research literature represent only four of the 41 attributes that have been used to define the quality of dial-a-ride services. To our knowledge, no study has yet attempted to align the specifications used in OR models with the customer requirements assessed through discussion groups and surveys.

3.2 The impact of several factors on quality

A number of studies have been conducted to examine the impact of several factors on quality in dial-a-ride services. These factors include the size and the type (i.e., public or private) of the organizations providing the service, the operational rules used by the organization, the hiring of subcontractors to perform the service, the consideration

Attributes	**Authors**	
Difference between actual and desired delivery time	Beaudry et al. (2007) Jorgensen et al. (2007) Melachrinoudis et al. (2007) Coslovich et al. (2006) Dessouky et al. (2003) Teodorovic and Radivojevic (2000) Toth and Vigo (1997) Dumas et al. (1990)	Jaw et al. (1986) Sexton and Choi (1986) Roy et al. (1985) Sexton and Bodin (1985) Jaw (1984) Sexton and Bodin (1980) Wilson and Miller (1977) Wilson et al. (1976)
Time windows	Melachrinoudis et al. (2007) Wolfler Calvo and Colorni (2007) Cordeau (2006) Rekiek et al. (2006) Wong and Bell (2006) Xiang et al. (2006) Diana and Dessouky (2004) Cordeau and Laporte (2003) Fu (2002) Colorni and Righini (2001) Teodorovic and Radivojevic (2000) Borndörfer et al. (1997)	Toth and Vigo (1996) Ioachim et al. (1995) Madsen et al. (1995) Desrosiers et al. (1991) Dumas et al. (1989) Dumas (1989) Desrosiers et al. (1986) Jaw et al. (1986) Bélisle et al. (1985) Psaraftis (1983) Armstrong and Garfinkel (1982)
Waiting time during the ride	Jorgensen et al. (2007) Madsen et al. (1995)	Wilson and Miller (1977) Wilson et al. (1976)
Waiting time before pickup	Psaraftis (1980) Wilson and Miller (1977)	Wilson et al. (1976)
Total waiting time	Diana (2004)	

Attributes	**Authors**	
Maximum ride time	Beaudry et al. (2007) Cordeau (2006) Wong and Bell (2006) Xiang et al. (2006) Cordeau and Laporte (2003) Dessouky et al. (2003)	Teodorovic and Radivojevic (2000) Toth and Vigo (1997) Toth and Vigo (1996) Jaw et al. (1986) Jaw (1984) Roy et al. (1985)
Excess of maximum ride time	Jorgensen et al. (2007)	
Ratio of actual ride time on direct ride time	Wolfler Calvo and Colorni (2007) Colorni and Righini (2001)	Jaw (1984)
Excess ride time over direct time	Jorgensen et al. (2007) Melachrinoudis et al. (2007) Coslovich et al. (2006) Wong and Bell (2006) Diana and Dessouky (2004) Aldaihani and Dessouky (2003)	Fu (2002) Madsen et al. (1995) Roy et al. (1985) Sexton and Bodin (1985) Sexton and Bodin (1980)
Total ride time	Diana (2004) Psaraftis (1980) Psaraftis and Tharakan (1979)	Wilson and Miller (1977) Wilson et al. (1976)
Total time (between the call and the delivery time)	Wilson et al. (1976)	
Maximum number of stops while a user is on board	Armstrong and Garfinkel (1982)	

Table 7: Quality specifications used by operations researchers

of the environmental impact of the service, and the implementation of an automated system. Each of the following subsections describes one or several studies about these factors.

3.2.1 Size and type of organization

Following their study of the dimensions and attributes that can define quality, McKnight and Pagano (1984) attempted to determine the impact on quality of the size and the type of the organizations providing the dial-a-ride service. To this end, they developed a quality index and used it to compare 42 dial-a-ride providers in the greater Chicago area. The information about the providers was gathered through observation and interviews. The researchers grouped these service providers according to three different types: public organizations (26), private non-profit organizations (10) and private for-profit organizations (6). Their analysis of the effect of service size on service quality allowed them to conclude that the larger the organization providing the service, the higher the quality of the service. In fact, they developed a model that explains 50% of the variation in quality. In addition, they also noted that a service responding to occasional requests tends to have a higher quality coefficient than a service with a fixed route, but a lower quality coefficient than a service responding to regular requests, the efficiency of the latter being able to improve quality in a variety of ways.

Their analysis of the effect of organization type on service quality allowed them to conclude that quality increases if an "organization moves from public to private non-profit, [and from private non-profit] to private for-profit"(p.43). This impact can be explained primarily by the service availability (wider operating hours for private for-profit services) and by the access to vehicles. On the other hand, in terms of driver characteristics, reactivity and responsiveness, private for-profit services have a lower quality coefficient, which can be explained by the fact that these services are probably less personalized. In addition, the researchers have noted that public and private non-profit organizations tend to be smaller than private for-profit organizations, which corroborates their conclusions about organization size. In general, it is difficult to draw conclusions about organization size and type since the division into small groups makes the number in each sample too small for the results to be statistically significant. Ultimately, the researchers found a negative correlation between productivity and quality in dial-a-ride services.

Unlike the conclusions of the above study, the one by the *Direction du transport terrestre des personnes* (2006) highlights that in Quebec, "the quality of the service is connected to the size the adapted transportation organization (ATO) in several respects: the larger ATOs, which serve several thousands of users, have difficulty providing services that are as satisfactory for users as those that are smaller" (p. 15). The difference in the conclusions of this study and that by McKnight and Pagano (1984) can be

explained in several ways. First, the contexts of the two jurisdictions are probably different and the studies were conducted two decades apart. In addition, the attributes used to measure quality were probably not the same in the two studies. Thus, it is very difficult to draw general conclusions that would be applicable to all dial-a-ride service organizations. However, certain conclusions, such as the fact that there is a negative correlation between productivity and quality in dial-a-ride services, seem to be unanimous. In fact, according to Cyra et al. (1988), "balancing the demands of efficiency [(i.e., providing the service at the lowest cost)] versus effectiveness [(i.e., respecting the quality objectives)] is often the greatest challenge of paratransit [dial-a-ride] services"(p.77). This opinion is echoed by several authors in the operations research literature. For example, Cordeau and Laporte (2007) mention that most dial-a-ride services are characterized by the presence of two conflicting objectives: the desire to minimize operational costs and the desire to minimize user inconvenience, thus maximizing quality.

3.2.2 Operational rules

Bélisle et al. (1985) attempted to determine the impact of different operational rules on the productivity of dial-a-ride services. They considered quality in terms of service delays (with respect to fifteen minute time windows), excess ride times (with respect to the direct ride time), and the minibus/taxi ratio. In this study, the different operational rules concern reservation policies and the composition of the vehicle fleet. Two types of reservation policies were considered: either a customer calls the company and obtains a reservation immediately (no call-back), or the company calls the customer back several hours later to confirm the reservation (call-back). The operational rules concerning the vehicle fleet are linked to its composition: either the fleet is composed of only minibuses, or it is primarily composed of taxis. In addition, the study considers that the vehicles are equipped with phones to allow the dispatcher to give information to the driver in real time (e.g., about cancellations, additions). Bélisle and his team analyzed the following three scenarios: 1) minibus and call-back, 2) minibus and no call-back, and 3) taxi and no call-back.

To complete their analyses, the authors generated customer requests through simulation, with a high cancellation rate. To dispatch the requests among the vehicles, they used two algorithms, one based on a technique involving parallel insertion and one based on column generation. Both techniques were applied to construct the route based on regular requests and to add new requests if the call-back option was used; otherwise, they only applied the insertion technique. The performance indicators used to compare the different scenarios were the following: 1) driver productivity, 2) vehicle productivity, 3) non-empty vehicle productivity, and 4) taxi/minibus productivity. Comparing scenarios 1 and 2 led to the following conclusions: the overall productivity

for scenario 1 is a little higher than the one for scenario 2, and there is little difference in the quality measurements. The comparison of scenario 3 with the first two led to the conclusion that it is better to send a taxi to users who are able to take one. The quality of scenario 3 is comparable to that of scenarios 1 and 2. Thus, the researchers concluded that a dial-a-ride service is similar to a taxi system, and that the choice between a call-back policy and a no-call-back policy depends on the organization and has no real impact on service quality.

Venter (2001) also analyzed the impact of reservation policies on dial-a-ride users. This researcher compared, from a social point of view, the difference between a reservation policy requiring reservations to be made at least one day in advance, and a policy allowing same day reservations. The researcher first analyzed the reasons for the trips and how long in advance they were planned, without taking into account the constraint of transportation reservations. He found that activities connected to work, school or sports were often planned more than a week in advance and represented 53% of the trips analyzed. Only 25% of the trips were not planned more than one day in advance and these often involved a leisure activity. In addition, the trips requiring an attendant or the longer trips were mostly planned in advance, and older people or those with children tended to plan their trips at least one day in advance. He thus concluded that the impact of the reservation policy depends on the user group. Those with severe mobility constraints are the most affected by reservation policies of less than one day in advance because they constitute a captive user group, which is totally dependent on the dial-a-ride services and because they have no alternative for trips planned on short notice.

3.2.3 Internal or sub-contracted operations

Mumayiz (1987) compared the situation before and after hiring sub-contractors to run the adapted transportation service for the City of Chicago. To this end, he used the dimensions used by Pagano and McKnight (1983) and the advice of a private consulting firm. To compare the services before and after, Mumayiz used performance indicators inspired by the attribute lists of Pagano and McKnight (1983) to develop several indicators, which are presented in Table 8. In this study, Mumayiz used only the three indicators shown in bold in the table: cost per passenger per trip, total number of trips, and operating hours. Mumayiz concluded that the situation using subcontractors is less costly and leads to an increase in the number of hours that the service is available as well as an increase in the number of trips.

Dimensions	Measures	Methods of collection
Cost and efficiency	**Cost per passenger per trip**	Database
	No shows per reservation	Database
	Cancellations per reservation	Database
Market penetration and characteristics	**Total passenger trips**	Database
	Percentage of attendants of total riders	Database
	Subscription ratio	Database
	Passenger trip by fare type	Database
	Percentage of wheelchair users	Database
Reliability	Percent on-time performance	Survey
	Average travel time	Database
	Vehicle miles per road call	Database
	Notification of delays	Policies
	Missed trips	Database and Survey
Extent of service	**Hours of service**	Policies
	Total trips made per trips requested	Database
Convenience	Reservation length	Policies
	Accommodation to changes in trip plans	Survey
	Return reservation	Survey
Safety	Accidents per 1000 passenger trips	Database
	Passenger-related incidents and non-traffic accidents	Database
	Driver training	Policies
	Handicapped facilities	Inspection
Vehicle characteristics	Ease of use for handicapped riders	Survey
	Condition and cleanliness of vehicles	Survey
	Comfort of ride	Survey
Driver characteristics	Sensitivity to needs of passengers	Survey
	Courtesy and professionalism	Survey
Ease of dealing with office	Courtesy of telephone operators	Survey
	Ease of obtaining information	Survey
General and administrative	Number of complaints reported by riders	Database

Table 8: Performance measures suggested by Mumayiz (1987)

3.2.4 Environmental impact of the service

The optimization of routing and scheduling in dial-a-ride problems, while taking the environmental impact of the service into account, was investigated by Dessouky et al. (2003). To do so, these authors have modified the algorithm of Jaw et al. (1986) by adding in the objective function a term representing environmental costs. These researchers have considered different weights associated to the term of environmental costs. In their study, Dessouky et al. represent the level of service using the deviation from the time windows and a maximum ride time. They conclude that minimizing environmental costs have only a minimal negative impact on the level of service and operational costs.

3.2.5 Implementation of an automated system

The implementation process for an automated routing and scheduling system and its impact on the quality of the service was studied by Pagano et al. (2001). To this end, the authors conducted a survey with dial-a-ride service operators. The quality performance indicators were punctuality, customer satisfaction, and real-time information provided to customers. The researchers found five types of changes in quality after the implementation of an automated system. First, the system allowed an increase in the amount of service offered to the community since it took less time to provide more trips. Second, the automated reservation system was more rapid and more efficient than the non-automated system. Third, punctuality improved since the vehicles arrived on time more often. Fourth, trip request refusals occurred less frequently. Fifth, the organization was able to offer real-time information to its customers. However, despite the improvements reported by the service operators, several of them stated that they had not seen a change in the number of customer complaints. In conclusion, these researchers argued that the operators do not take advantage of all the possibilities offered by the automated system.

In 2002, the same researchers published another study on the impact of automated systems on service quality. It was based on interviews with transportation service managers and dispatchers and on a survey of the service users. The survey method was not the same before and after the implementation and thus the results could be biased. The researchers pointed out that implementing the automated system increased the speed with which the phone was answered and increased the frequency of vehicle punctuality, though they drew no conclusions about the friendliness of the drivers. The researchers also pointed out that implementing the system, which primarily aims to increase productivity, can have negative consequences on service quality. For example, after implementing the automated service, the number of times a user was put on hold during the reservation process increased and the ride times also increased. Thus,

the researchers concluded that implementing an automated system for routing and scheduling has several positive impacts, but can also negatively affect service quality.

To summarize, the impact on quality of various factors (e.g., organization size, organization type, operational policies, use or non-use of subcontractors, consideration of environmental costs, and implementation of an automated system) has not been studied by many researchers. To our knowledge, a single paper (Paquette et al., 2007) has attempted to establish the relationship between operational costs and service quality, though it was not conducted with real data. Studying the quality standards and specifications that should be adopted and the costs of adopting them would allow a better understanding of the possible trade-offs between quality and operational costs. To our knowledge, no study has yet considered the alignment of quality standards (technical quality, internal management practices) and customer requirements (customer-based quality, external management practices) in the sector of dial-a-ride services. Thus, other studies on this theme could lead to a better comprehension of quality in the dial-a-ride service sector.

4 Conclusions

Studying quality in the service sector is still a recent development, and much research remains to be done. Several methods or approaches currently used in the manufacturing sector could probably be adapted to the service sector. However, several researchers have pointed out that there is no universally accepted definition of quality, which is a prerequisite for this kind of research. In addition, researchers have observed that the quality management is inter-functional and requires the constant implication of managers. Since studies of quality in dial-a-ride services are even less prevalent than those about service quality in general, the research that has been carried out in the service sector in general could help to orient the research effort in the specific sector of dial-a-ride services. Much remains to be done before the trade-offs that exist between costs, operational policies and quality in dial-a-ride services can be better understood.

Acknowledgements

This work was supported by the Social Sciences and Humanities Research Council of Canada and by the Canadian Natural Sciences and Engineering Research Council under grants 227837-04 and 39682-05. This support is gratefully acknowledged.

References

Albrecht, K. & R. Zemke (1985). *Service America*. Homewood, Illinois: Dow Jones-Irwin.

Aldaihani, M. & M. M. Dessouky (2003). Hybrid scheduling methods for paratransit operations. *Computers & Industrial Engineering* 45, 75–96.

Armstrong, G. R. & R. S. Garfinkel (1982). Dynamic programming solution of the single and multiple vehicle pickup and delivery problem with application to dial-a-ride. Working paper 162, University of Tennessee.

Beaudry, A., G. Laporte, T. Melo, & S. Nickel (2007). Dynamic transportation of patients in hospitals. Submitted for publication.

Bélisle, J., F. Soumis, S. Roy, J. Desrosiers, Y. Dumas, & J.-M. Rousseau (1985). The impact on vehicle routing of various operational rules of a transportation system for handicapped persons. Working paper G-84-14, GERAD, HEC Montréal, Canada.

Berbeglia, G., J.-F. Cordeau, I. Gribkovskaia, & G. Laporte (2007). Static pickup and delivery problems: A classification scheme and survey. *TOP* 15, 1–31.

Bitner, M. J. & A. R. Hubbert (1994). Encounter satisfaction versus overall satisfaction versus quality. In R. T. Rust and R. L. Oliver (Eds.), *Service Quality: New directions in theory and practice*, pp. 72–94. London: SAGE Publications.

Booms, B. H. & M. J. Bitner (1981) Marketing strategies and organization structures for service firms. In J. H. Donnelly and W. R. George (Eds.), *Marketing of Services*, pp. 7–51. Chicago: American Marketing Association.

Borndörfer, R., M. Grötschel, F. Klostermeier, & C. Küttner (1997). Telebus Berlin: Vehicle scheduling in a dial-a-ride system. Technical report SC 97-23, Konrad-Zuse-Zentrum für Informationstechnik Berlin.

Colorni, A. & G. Righini (2001). Modeling and optimizing dynamic dial-a-ride problems. *International Transactions in Operational Research* 8, 155–166.

Cordeau, J.-F. (2006). A branch-and-cut algorithm for the dial-a-ride problem. *Operations Research* 54, 573–586.

Cordeau, J.-F. & G. Laporte (2003). A tabu search heuristic for the static multi-vehicle dial-a-ride problem. *Transportation Research Part B* 37, 579–594.

Cordeau, J.-F. & G. Laporte (2007). The dial-a-ride problem : models and algorithms. *Annals of Operations Research* 153, 29–46.

Cordeau, J.-F., G. Laporte, J.-Y. Potvin, & M. W. P. Savelsbergh (2007a). Transportation on demand. In C. Barnhart and G. Laporte (Eds.), *Handbooks in Operations Research and Management Science*, Volume 14, pp. 429–466. Elsevier, Amsterdam.

Cordeau, J.-F., G. Laporte, M. W. P. Savelsbergh, & D. Vigo (2007b). Vehicle routing. In C. Barnhart and G. Laporte (Eds.), *Handbooks in Operations Research and Management Science*, Volume 14, pp. 367–428. Elsevier, Amsterdam.

Coslovich, L., R. Pesenti, & W. Ukovich (2006). A two-phase insertion technique of unexpected customers for a dynamic dial-a-ride problem. *European Journal of Operational Research* 175, 1605–1615.

Cronin, J. J. & S. A. Taylor (1992). Measuring service quality: A reexamination and extension. *Journal of Marketing* 56, 55–68.

Curry, A. & D. Herbert (1998). Continuous improvement in public services - a way forward. *Managing Service Quality* 8, 339–349.

Cyra, D. J., M. J. Mulroy, & R. Jans (1988). An inventory of twelve paratransit service delivery experiences. *Transportation Research Record* 1170, 69–80.

Denson, C. R. (2000). Public sector transportation for people with disabilities: A satisfaction survey. *Journal of Rehabilitation* 66, 29–37.

Desrosiers, J., Y. Dumas, & F. Soumis (1986). A dynamic programming solution of the large-scale single-vehicle dial-a-ride problem with time windows. *American Journal of Mathematical and Management Sciences* 6, 301–325.

Desrosiers, J., Y. Dumas, F. Soumis, S. Taillefer, & D. Villeneuve (1991). An algorithm for mini-clustering in handicapped transport. Working paper G-91-02, GERAD, HEC Montréal, Canada.

Dessouky, M. M., M. Rahimi, & M. Weidner (2003). Jointly optimizing cost, service, and environmental performance in demand-responsive transit scheduling. *Transportation Research Part D* 8, 433–465.

Diana, M. (2004). Innovative systems for the transportation disadvantaged: toward more efficient and operationally usable planning tools. *Transportation Planning and Technology* 27, 315–331.

Diana, M. & M. M. Dessouky (2004). A new regret insertion heuristic for solving large-scale dial-a-ride problems with time windows. *Transportation Research Part B* 38, 539–557.

Direction du transport terrestre des personnes (2006). *Étude sur les besoins et la satisfaction de la clientèle*. Québec: Direction du transport terrestre des personnes. 66 p.

Dumas, Y. (1989). *Confection d'itinéraires pour le transport adapté*. Ph.D. thesis, École Polytechnique de Montréal.

Dumas, Y., J. Desrosiers, & F. Soumis (1989). Large scale multi-vehicle dial-a-ride problem. Working paper G-89-30, GERAD, HEC Montréal, Canada.

Dumas, Y., F. Soumis, & J. Desrosiers (1990). Optimizing the schedule for a fixed vehicle path with convex inconvenience costs. *Transportation Science* 24, 145–152.

Falcocchio, J. (1979). A methodology for evaluation the effectiveness of transportation improvements for the elderly and handicapped. Working paper, U.S. Department of Transportation.

Fu, L. (2002). Scheduling dial-a-ride paratransit under time-varying, stochastic congestion. *Transportation Research Part B* 36, 485–506.

Glauthier, R. E. & E. H. Ellis (1993). Measuring and tracking the demand for and performance of ADA paratransit services. Proceedings of the transportation research board: in solving ADA paratransit problems; How to cope with reality.

Grönross, C. (1984). A service quality model and its marketing implications. *European Journal of Marketing* 18, 36–44.

Grönross, C. (1990). *Service management and marketing: managing the moments of truth in service competition*. Lexington, MA: Lexington Books.

Gummesson, E. (1992). Quality dimensions: What to measure in service organizations. In T. A. Swartz, D. Bowen, and S. Brown (Eds.), *Advances in Services Marketing and Management*, pp. 177–205. Greenwich, CT: JAI.

Hauser, J. & D. Clausing (1988). The house of quality. *Harvard Business Review*, 63–73.

Ioachim, I., J. Desrosiers, Y. Dumas, M. Solomon, & D. Villeneuve (1995). A request clustering algorithm for door-to-door handicapped transportation. *Transportation Science* 29, 63–78.

Jaw, J.-J. (1984). *Solving large-scale dial-a-ride vehicle routing and scheduling problems*. Ph.D. thesis, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, MA.

Jaw, J.-J., A. R. Odoni, H. N. Psaraftis, & N. H. M. Wilson (1986). A heuristic algorithm for the multi-vehicle advance request dial-a-ride problem with time windows. *Transportation Research Part B* 20, 243–257.

Jorgensen, R. M., J. Larsen, & K. B. Bergvinsdottir (2007). Solving the dial-a-ride problem using genetic algorithms. *Journal of the Operational Research Society*, forthcoming.

Knutsson, S. (1999). Valuing rider quality attributes in the swedish special transport services. In *Urban Transport Systems, 2nd KFB-Research Conference*. Lund, Sweden: Lund University, Department of Technology and Society LTH.

Madsen, O. B. G., H. F. Ravn, & J. M. Rygaard (1995). A heuristic algorithm for a dial-a-ride problem with time windows, multiple capacities and multiple objectives. *Annals of Operations Research* 60, 193–208.

Maunder, D. A. C., C. J. Venter, T. Rickert, & J. Sentinella (2004). Improving transport access and mobility for people with disabilities. In *CILT Regional Conference, International Logistics and Transport: The Challenges Ahead*, Number PA4061/04, Dubai, UAE. Transport Research Laboratory.

McKnight, C. E. & A. M. Pagano (1984). Effect of size and type of organisation on quality of special transportation services. *Transportation Research Record* 973, 39–44.

McKnight, C. E., A. M. Pagano, & R. E. Paaswell (1986). Using quality to predict demand for special transportation. In *Behavioural research for transport policy : the 1985 International Conference on Travel Behaviour*. Noordwijk, The Netherlands: VNU Science Press.

Melachrinoudis, E., A. B. Ilhan, & H. Min (2007). A dial-a-ride problem for client transportation in a health-care organization. *Computers & Operations Research* 34, 742–759.

Mumayiz, S. A. (1987). The CTA special services to the mobility limited: Performance measures for evaluating quality of service. Working paper. Urban Transportation Center, University of Illinois at Chicago.

Oliver, R. (1997). *Satisfaction: A Behavioral Perspective on the Consumer*. New York: McGraw-Hill.

Pagano, A. M. & C. E. McKnight (1983). Quality of service in special service paratransit: The users' perspective. *Transportation Research Record* 934, 14–23.

Pagano, A. M., P. Metaxatos, & M. King (2001). How effective is computer-assisted scheduling and dispatching in paratransit: Results from a survey. *Transportation Research Record* 1760, 100–106.

Pagano, A. M., P. Metaxatos, & M. King (2002). Effect of computer-assisted scheduling and dispatching systems on paratransit service quality. *Transportation Research Record* 1791, 51–58.

Paquette, J., J.-F. Cordeau, & G. Laporte (2007). Une étude comparative de divers modèles pour le problème de transport à la demande. *INFOR*, forthcoming.

Parasuraman, A., V. A. Zeithaml, & L. L. Berry (1985). A conceptual model of service quality and its implications for future research. *Journal of Marketing* 49, 41–50.

Parasuraman, A., V. A. Zeithaml, & L. L. Berry (1988). SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing* 64, 12–40.

Parasuraman, A., V. A. Zeithaml, & L. L. Berry (1994). Reassessment of expectations as a comparison standard in measuring service quality: implications for further research. *Journal of Marketing* 58, 111–124.

Psaraftis, H. N. (1980). A dynamic programming solution to the single vehicle many-to-many immediate request dial-a-ride problem. *Transportation Science* 14, 130–154.

Psaraftis, H. N. (1983). An exact algorithm for the single vehicle many-to-many dial-a-ride problem with time windows. *Transportation Science* 17, 351–357.

Psaraftis, H. N. & G. G. Tharakan (1979). A dynamic programming approach to the dial-a-ride problem: An extension to the multi-vehicle case. Working paper R79-39, Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, MA.

Reeves, C. A. & D. A. Bednar (1994). Defining quality: alternatives and implications. *Academy of Management Review* 19, 419–445.

Rekiek, B., A. Delchambre, & H. A. Saleh (2006). Handicapped person transportation: An application of the grouping genetic algorithm. *Engineering Applications of Artificial Intelligence* 19, 511–520.

Rickert, T., C. J. Venter, & D. A. C. Maunder (2004). Accessible transport trends in latin america. In *10th International conference on mobility and transport for elderly and disabled people*, Number PA4058/04, Hamamatsu, Japan. Transport Research Laboratory.

Roy, S., J.-M. Rousseau, G. Lapalme, & J. A. Ferland (1985). Élaboration des routes et horaires de véhicules pour le transport adapté : l'algorithme. Working paper TP5596F, Université de Montréal : Centre de recherche sur les transports.

Rust, R. T. & R. L. Oliver (1994). Service quality: Insights and managerial implications from the frontier. In R. T. Rust and R. L. Oliver (Eds.), *Service Quality: New directions in theory and practice*, pp. 1–19. London: Sage Publications.

Rust, R. T., A. J. Zahorik, & T. L. Keiningham (1996). *Service marketing*. New York: HarperCollins.

Schneider, B. & S. S. White (2004). *Service Quality, Research Perspectives*. London: Sage Publications.

Sexton, T. R. & L. D. Bodin (1980). The single vehicle many to many routing and scheduling problem with desired delivery times. University of Maryland.

Sexton, T. R. & L. D. Bodin (1985). Optimizing single vehicle many-to-many operations with desired delivery times. *Transportation Science* 19, 378–410.

Sexton, T. R. & Y.-M. Choi (1986). Pickup and delivery of partial loads with soft time windows. *American Journal of Mathematical and Management Sciences* 6, 369–398.

Shostack, G. L. (1992). Understanding services through blueprinting. *Advances in Services Marketing and Management* 1, 75–90.

Storbacka, K., T. Strandvik, & C. Grönross (1994). Managing customer relationships for profit: The dynamics of relationship quality. *International Journal of Service Industry Management* 5, 21–38.

Stuart, F. I. & S. S. Tax (1996). Planning for service quality: an integrative approach. *International Journal of Service Industry Management* 7, 58–77.

Teodorovic, D. & G. Radivojevic (2000). A fuzzy logic approach to dynamic dial-a-ride problem. *Fuzzy Sets and Systems* 116, 23–33.

Toth, P. & D. Vigo (1996). Fast local search algorithms for the handicapped persons transportation problem. In I. H. Osman and J. P. Kelly (Eds.), *Meta-Heuristics: Theory and Applications*, pp. 677–690. Kluwer, Boston.

Toth, P. & D. Vigo (1997). Heuristic algorithms for the handicapped persons transportation problem. *Transportation Science* 31, 60–71.

Van Looy, B., P. Gemmel, S. Desmet, R. Van Dierdonck, & S. Serneels (1998). Dealing with productivity and quality indicators in a service environment: some field experiences. *International Journal of Service Industry Management* 9, 359–376.

Venter, C. J. (2001). Potential effects of next-day reservation policies on users of americans with disabilities act paratransit systems. *Transportation Research Record* 1760, 128–134.

Venter, C. J., J. Sentinella, T. Rickert, D. A. C. Maunder, & A. Venkatesh (2004). *Enhancing the Mobility of Disabled People: Guidelines for Practitioners* (TRL ed.). Crowthorne, UK: Department for International Development (DFID).

Wilson, N. & E. Miller (1977). Advanced dial-a-ride algorithms research project, phase II: Interim report. Working paper MA-09-0071, Massachusetts Institute of Technology, Cambridge, MA.

Wilson, N. H. M., R. W. Weissberg, & J. Hauser (1976). Advanced dial-a-ride algorithms research project: Final report. Working paper R-76-20, Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, MA.

Wolfler Calvo, R. & A. Colorni (2007). An effective and fast heuristic for the dial-a-ride problem. *4OR: A Quarterly Journal of Operations Research* 5, 61–73.

Wong, K. I. & M. G. H. Bell (2006). Solution of the dial-a-ride problem with multi-dimensional capacity constraints. *International Transactions in Operational Research* 13, 195–208.

Xiang, Z., C. Chu, & H. Chen (2006). A fast heuristic for solving a large-scale static dial-a-ride problem under complex constraints. *European Journal of Operational Research* 174, 1117–1139.

Zeithaml, V. A., L. L. Berry, & A. Parasuraman (1988). Communication and Control Processes in the Delivery of Service Quality. *Journal of Marketing* 52, 35–48.

Zeithaml, V. A. & A. Parasuraman (2004). *Service Quality*. Cambridge, MA: Marketing Science Institute.