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CHAPTER 1

QUALITY OF NURSING SCHEDULES

In most health care organizations, nursing care has to be provided continuously. This means that this process of providing nursing care goes on twenty-four hours a day, seven days a week, and fifty-two weeks a year. Consequently, nurses have to work during day shifts, evening shifts, and night shifts, and often on irregular working days, such as holidays and weekends. The task of arranging these shifts is generally called nurse scheduling.

This thesis describes a study which investigated the task of nurse scheduling. The present chapter introduces this subject of study. The first section describes the context of this task, which is nursing management, and deals with the relevance of this study from a management point of view. The second section discusses the societal relevance of this study. This societal relevance is related to the consequences of nursing schedules for both nurses and patients. The scientific relevance of this study, which is the subject of the third section, is a new approach to supporting nurse scheduling. This chapter ends with preliminary research questions and an outline of this thesis.

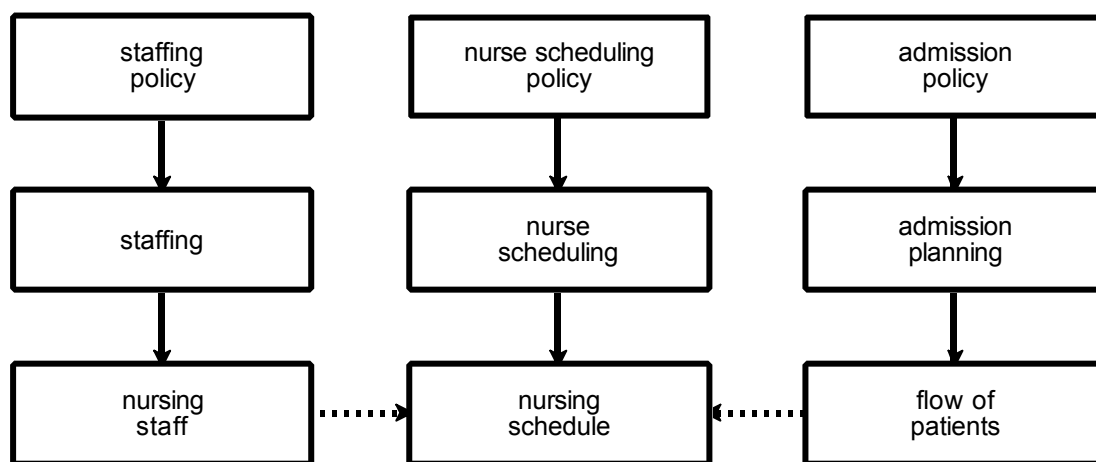
1.1 NURSING MANAGEMENT

Health care organizations are mostly divided into a number of nursing units (see Landman & Van den Boom, 1991, pp. 190-192). The director of a nursing unit is called a nurse administrator (see also Kedzierski & Vlemmix, 1992). One of the most important functions of the nurse administrators is to gear the deployment of nurses to the patients admitted to the nursing unit (Gallagher, 1987). This section discusses the characteristics of this attunement. The next subsections describe policies and planning related to this attunement, its levels of planning, definitions, and consequences.

1.1.1 Policies and planning of nurses and patients

The numbers of nurses working at a nursing unit is a result of the process of nursing staff planning, mostly referred to as staffing. The staffing policy controls this process of staffing (see Louwies, 1984, pp. 81-91). This staffing policy determines, for instance, the ratios per nurse category (e.g. registered nurses, licensed practical nurses and nursing assistants) at each nursing unit.

Figure 1.1 POLICIES AND PLANNING OF NURSES AND PATIENTS



On the other hand, the numbers of patients admitted to a nursing unit is a result of the process of admission planning (see also De Vries, 1984b). The admission policy controls this process of admission planning (e.g. Hogewind, 1988; Kusters, 1988, pp. 71-72; Lettink, 1990, p. 394). This admission policy determines, for instance, the types of patients admitted to each nursing unit.

Nursing schedules attune the nurses working at the nursing unit to the patients admitted to this nursing unit. The process of nurse scheduling determines the features of these nursing schedules (see Diekema, 1984, pp. 55-65). The nurse scheduling policy controls this process of nurse scheduling (see Kedzierski, 1984, pp. 15-16). This nurse scheduling policy determines, for instance, the procedure for assigning short time days (see also De Vries, 1984a).

Figure 1.1 shows these three management levels of the attunement of nurses and patients. The top levels are the policy levels. The intermediate levels concerns the processes of planning. And the bottom levels represent the outcomes of these planning processes.

1.1.2 Levels of planning

Anthony (1965) distinguishes three different levels of planning: strategic, tactical, and operational planning. The three types of planning shown in figure 1.1 (i.e. nursing staff planning (or staffing), admission planning and nursing schedule planning (or nurse scheduling)) are divided on the basis of these three levels (see also De Vries, 1988, pp. 43-44).

Strategic nursing staff planning involves the determination of the types of personnel to be employed on a permanent basis. Tactical nursing staff planning involves determining the numbers of personnel assigned to a nursing unit. This tactical nursing staff planning mostly involves a period of about a year. This tactical staffing is mostly referred to as the ‘staffing problem’ (see Warner, 1976). Operational nursing staff planning involves the ‘allocation’ of the work tasks to the nursing personnel. Operational nursing staff planning involves a period of one day. This study will refer to operational nursing staff planning as the ‘task allocation problem’.

Strategic admission planning involves the determination of the types of patients to be admitted to each nursing unit. Tactical admission planning involves the determination of the day and time of admission per patient. This tactical admission planning is also referred to as ‘inpatient admission scheduling’ (see Smith-Daniels et al., 1988, pp. 897-899). Operational admission planning concerns the assignment of each patient to a room and a bed.

Strategic nurse scheduling concerns scheduling decisions involving a period of about a year, covering, for example, the planning of each nurse’s vacations. Tactical nurse scheduling involves determining those days and shifts when each member of the nursing staff is to report for work in the predetermined scheduling horizon. In general, the length of this predetermined scheduling horizon varies from two to six weeks. This tactical nurse scheduling is mostly referred to as the ‘nurse scheduling problem’ (see Ahuja & Sheppard, 1975; Warner, 1976). Operational nurse scheduling concerns rescheduling caused by illness, on a daily basis.

1.1.3 Definitions of nurse scheduling

This study focuses on the nurse scheduling problem mentioned above. This problem is primarily a tactical problem (see also Arthur & Ravindran, 1981, p. 55; Mietus, 1994, p. 18). Mostly, this tactical nurse scheduling is simply referred to as nurse scheduling, but ‘nurse shift scheduling’ (see Chen & Yeung, 1992) or

‘nursing staff scheduling’ (see Okada & Okada, 1988) are also used. Nurse scheduling is the procedure for providing nursing care by assigning shifts to nursing personnel (Rowland & Rowland, 1985). To be more specific, nurse scheduling is the process of determining when each nurse of a nursing unit will be on or off duty, which shift will be worked, by whom, and how weekends, the number of consecutive days worked, requests, and vacations will be accounted for (Fluharty, 1988, p. 5).

Nurse scheduling involves three dimensions (see also Oldenkamp, 1992a, p. 70; Oldenkamp & Simons, 1994, p. 2). The first dimension concerns the nursing staff. Members of this nursing staff might differ concerning their professional category (e.g. registered nurses, licensed practical nurses, nursing assistants, and student nurses or trainee nurses), or their labor contract (e.g. full time or part time). The second dimension concerns the days of the schedule period. These days can be divided into two types: special working days (i.e. (public) holidays or weekends), and regular working days (i.e. all remaining days). The third dimension of nurse scheduling concerns the shifts to be assigned to a member of the nursing staff on a particular day of the schedule period. These shifts can be divided into two groups: ‘productive’ shifts (i.e. day shifts, evening shifts, and night shifts) and ‘unproductive’ shifts (e.g. day off or special leave). In the case of the nurse scheduling problem, each (productive) shift’s beginning and duration is fixed.

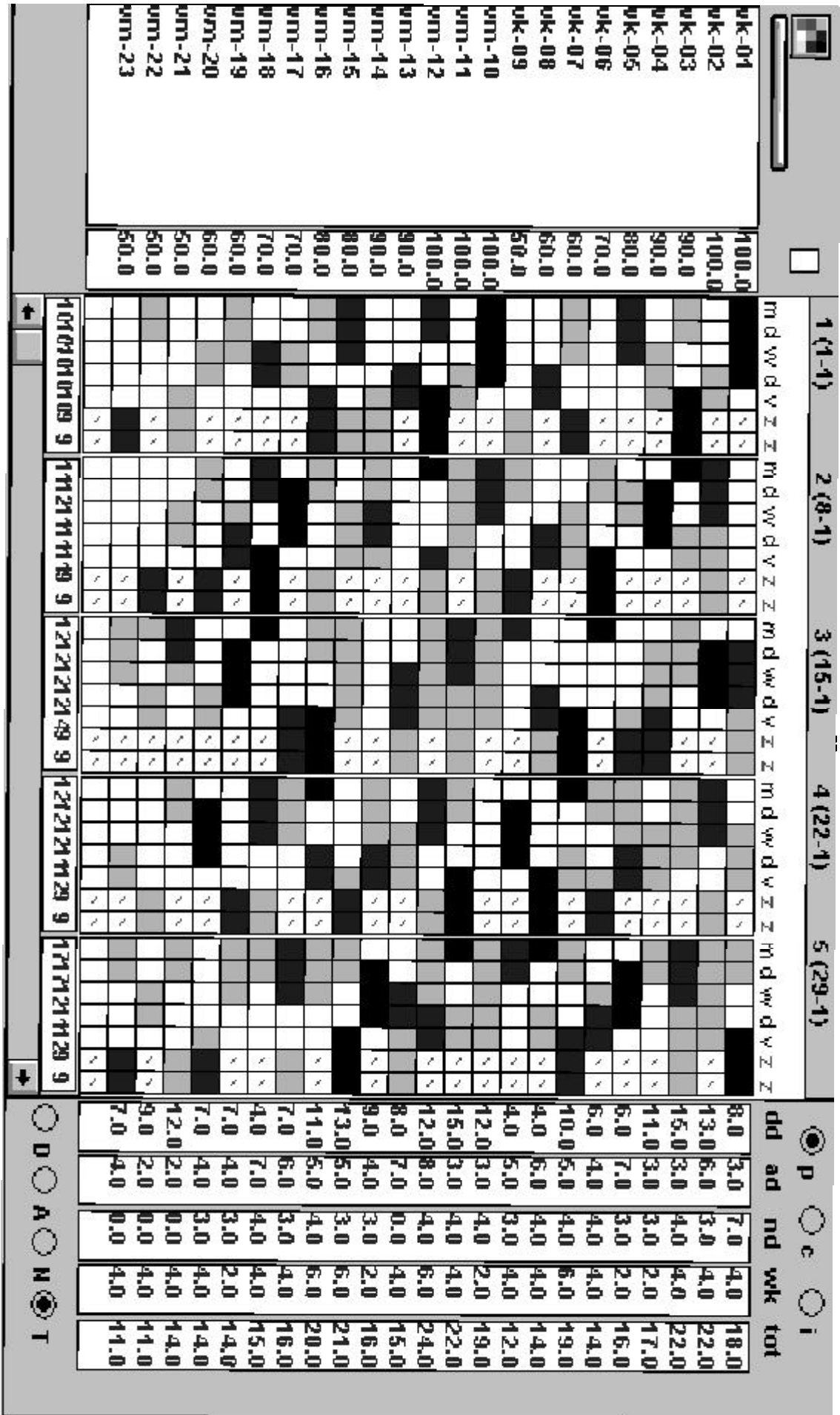
1.1.4 Consequences of nursing schedules

The outcome of the nurse scheduling task is the nursing schedule. Figure 1.2 shows this type of nursing schedule.

Two of the three dimensions of nurse scheduling are explicitly represented in a nursing schedule. The horizontal dimension represents the days of the schedule period, while the members of the nursing staff are represented vertically. The third dimension of nurse scheduling is implicitly represented in the cells of the nursing schedule. The color (i.e. grey shade) of each cell represents the type of shift assigned to the corresponding nurse on the corresponding day.

Nursing schedules have a number of consequences for the performance of the nursing unit. Fitzpatrick, Farrell and Richter-Zeunik (1987) found several of these types of (negative) consequences, such as unnecessary overtime, high charges for agency nurses, frequent schedule changes and nurse dissatisfaction with assignments that led to absenteeism and a high turnover rate (p. 10). For

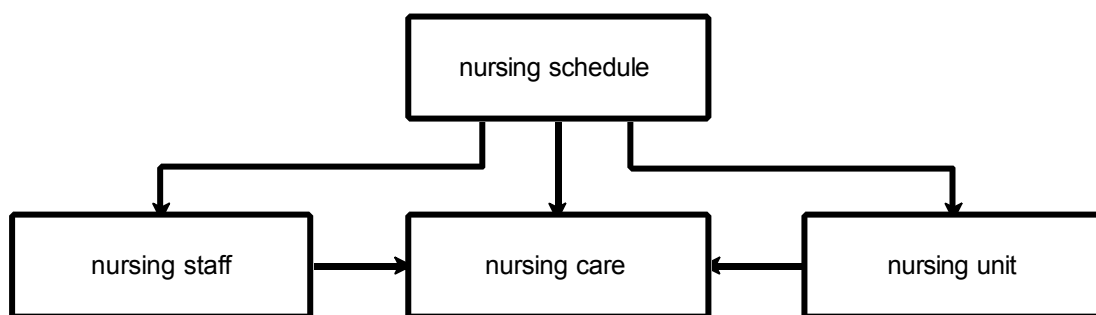
Figure 1.2 A NURSING SCHEDULE



with assignments that led to absenteeism and a high turnover rate (p. 10). For example, the nurse coded as 'vm-11' in figure 1.2 works nine days in a row starting in the third week. This type of working schedule might have negative consequences for this nurse (e.g. low job satisfaction).

Below, the consequences of nursing schedules are divided into three parts: the effectiveness in providing nursing care, the efficiency of a nursing unit and the job satisfaction of the nursing staff. Figure 1.3 shows this division of the consequences of nursing schedules for the performance of the nursing unit.

Figure 1.3 CONSEQUENCES OF NURSING SCHEDULES FOR THE PERFORMANCE OF THE NURSING UNIT



The main consequences of nursing schedules concern the effectiveness in providing nursing care. The effectiveness is mostly specified as the continuity in nursing care, because this continuity is an important requirement for the provision of high-quality nursing care. Nursing schedules determine this continuity in this nursing care (see Bisseling, 1993; Marquis & Huston, 1994).

Other consequences of nursing schedules concern the working hours of the nursing staff. A nursing schedule determines when each nurse will be on or off duty and which shift will be worked. This determination of the nurses' working hours strongly affects their social and family life (see Hung, 1992; Chen & Yeung, 1992; Oldenkamp, 1992b). As an impairment of social and family life decreases job satisfaction (see also Jansen et al., 1986; Jansen, 1987), nursing schedules affect the job satisfaction of the nursing staff.

The remaining consequences of nursing schedules concern the nursing unit. Nursing schedules determine both the number of nurses and the amount of nursing expertise present in the nursing unit at each time of day. These numbers of nurses and amounts of nursing expertise strongly influence the cost of providing the daily nursing care (see Gallagher, 1987; Fluharty, 1988). And because the salaries paid to nursing personnel constitute the largest single cost element in hospitals (e.g. Kao & Queyranne, 1985; Smith-Daniels et al., 1988; Ozkarahan & Bailey, 1988, p. 306), nursing schedules strongly affect the efficiency of a nursing unit. For example, there are too many nurses scheduled on the Monday and Tuesday of the fifth week in figure 1.2, which decreases the efficiency of the presented nursing schedule.

Furthermore, both job satisfaction and the efficiency of a nursing unit will also affect the quality of the nursing care, because an under-motivated nursing staff

or too few (registered) nurses per shift will reduce this quality. Figure 1.3 also shows these indirect consequences of nursing schedules.

1.2 PLURIFORMITY OF NURSING SCHEDULE QUALITY

Nurse scheduling involves three parties with different interests. These parties are the nursing personnel working at the nursing unit, the patients admitted to this nursing unit, and the (financial) management of the nursing unit. These parties can strongly differ in their views on the intended quality of nursing schedules. The following subsections discuss these different views in more detail.

1.2.1 The nurses' view on nursing schedule quality

Nurses have a strong interest in nurse scheduling because their social and family life is highly restricted by the scheduled working hours. Also the health of nurses is strongly influenced by the irregularity in working hours (see Van Emmerik, 1992a; 1992b). To reduce the health impairment for nurses, Dutch nurse schedulers are obliged to take into account a number of regulations (Grunveld, Van der Speld & Overbosch, 1993).

Furthermore, nurses in most nursing units can specify general preferences and incidental requests. These preferences concern, for example, a fixed evening off (e.g. sports evening), while special requests mostly concern a day off (e.g. a wedding). By means of these preferences and requests, nurses can influence their own working schedules. The nurse scheduler decides which of these preferences and requests can be granted.

Summarizing, the nurses' view on nursing schedule quality concerns the impairment of health and of social and family life. To stress this view, Bisseling (1993, p. 13) introduced the concept of 'schedule contentment', which he defined not only as the employee's contentment concerning the scheduled shifts, but also as the contentment about several 'schedule risk criteria' (see also Jansen, 1987), the (in)convenience of the working hours, the potential for recovery and the employee's opinion about her or his health.

1.2.2 The patients' view on nursing schedule quality

Because high-quality nursing care is strongly influenced by the continuity in the daily scheduled nurses (see Marquis & Huston, 1994), a second party with an interest in nurse scheduling is the patients. Furthermore, the numbers of nurses and their levels of nursing expertise also influence the quality of nursing care. Patients will prefer health care organizations with nursing schedules that facilitate high-

quality nursing care. Patient-centred health care organizations will therefore try to provide patient care with high continuity. This means that a patient-centred management view includes this patients' view. Summarizing, the patients' view on nursing schedule quality concerns the continuity in the daily scheduled nurses, together with a sufficient amount of nursing expertise.

1.2.3 The management view on nursing schedule quality

A third party with an interest in nurse scheduling is the (financial) management of the nursing unit. This interest is based on the fact that the efficiency of a nursing unit determines the costs to a large extent. This not only involves the total of the monthly salaries, but also a number of problems related to nurse scheduling. High turnover, absenteeism and poor job performance are prevailing problems for nursing management in health care organizations (Richman, 1987; Hung, 1992). The stressful working environment, the uncompetitive salary, the lack of a positive career image and the irregular working schedules are factors which contribute to these problems (Wagner, 1988). A management view on nursing schedule quality will therefore include these factors. Summarizing, the management view on nursing schedule quality concerns the effect of these working schedules on the efficiency of the nursing unit.

1.2.4 The nurse scheduler's view on nursing schedule quality

When arranging nursing schedules, nurse schedulers, as administrators of the nursing unit, take into account all the consequences nursing schedules have for the performance of the nursing unit. These consequences are stressed by the interests of the nursing unit's nurses, patients or financial management. Mostly, these interests are conflicting, which makes it impossible to arrange a schedule which is best according to all views. Therefore, a nurse scheduler tries to arrange a nursing schedule which is as good as possible taking into account all the consequences of this schedule for the parties involved. However, the priorities given to each of these consequences might very well differ per health care organization, nursing unit or nurse scheduler.

1.3 DECISION SUPPORT FOR NURSE SCHEDULING

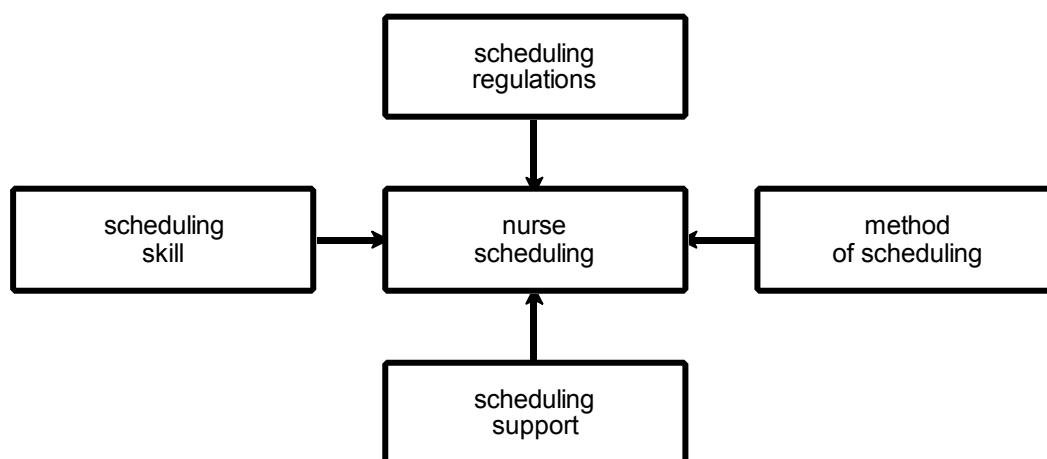
The nursing schedule is an outcome of the process of nurse scheduling. An improvement of nursing schedule quality will therefore require an improvement in the process of nurse scheduling. The following subsection discusses four types of influence on nurse scheduling that could facilitate an improvement. The rest of this section will then discuss one of these influences in more detail.

1.3.1 Influences on nurse scheduling

The actual process of nurse scheduling is influenced by the scheduling skill of the nurse scheduler, the method of scheduling applied to arrange nursing schedules, all kinds of scheduling regulations and all kinds of scheduling support. Figure 1.4 shows these four influences on nurse scheduling.

Each of these four influences on nurse scheduling can be used to increase the quality of the resulting nursing schedules. Increasing the skill of nurse schedulers involves, for example, additional training programmes. Examples of increasing nursing schedule quality by means of improving the method of scheduling are given by Diekema (1994) and De Vries-Griever and colleagues (1994). Regulations (by Dutch law) designed to improve the quality of nursing schedules are described by Grunveld, Van der Speld and Overbosch (1993). The fourth influence on nurse scheduling concerns the support of this task by means of computer programs or other kind of tools.

Figure 1.4 INFLUENCES ON NURSE SCHEDULING



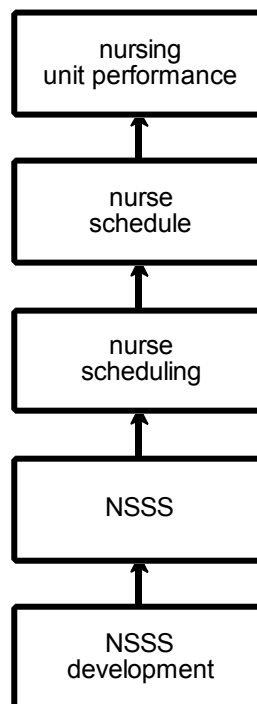
For more than two decades, researchers have been trying to develop computer programs in order to support the task of nurse scheduling (see Warner & Prawda, 1972; Arthur & Ravindran, 1981; Ozkarahan & Bailey, 1988; Okada, 1992; Chen & Yeung, 1992; Mietus, 1994; Weil et al., 1995). The present study also follows this management informatics approach. It focuses on the influence of the support of computer programs on the task performance of nurse scheduling. The next subsection describes this influence as a link in a quality chain.

1.3.2 The quality chain of nurse scheduling support systems

During the last decades, many scientific studies have been conducted in order to

support the task of nurse scheduling by means of a computer program (see Warner & Prawda, 1972; Arthur & Ravindran, 1981; Ozkarahan & Bailey, 1988; Okada, 1992; Chen & Yeung, 1992; Weil et al., 1995). The idea behind these studies is that the performance of the task of nurse scheduling can be improved by using a nurse scheduling support system (NSSS). Hofstede (1992, pp. 107-135) shows that this type of intended improvement is one link of a quality chain (see also Simons & Verheijen, 1991, pp. 23-25). Figure 1.5 shows this quality chain applied to nurse scheduling.

Figure 1.5 THE QUALITY CHAIN OF NURSE SCHEDULING SUPPORT SYSTEMS

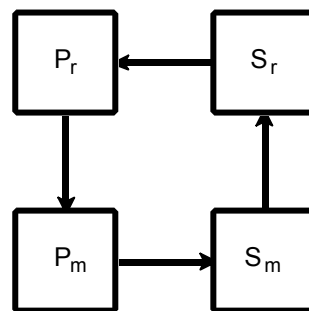


The final link in this quality chain of nurse scheduling support systems concerns the consequences of nursing schedules for the performance of the nursing unit. Or to put it differently, the quality of nursing schedules affects the ‘quality’ of the nursing unit. Furthermore, the nursing schedule quality is affected by the ‘quality’ of the nurse scheduling task performance. And as stated above, this quality of the nurse scheduling task performance is affected by the ‘quality’ of the nurse scheduling support system. Finally, the quality chain of nurse scheduling support systems starts with the link between the ‘quality’ of the development of the nurse scheduling support system and the resulting nurse scheduling support system.

The objective of this study is to increase the quality of nursing schedules by operationalizing the quality concept in such a way that it positively influences all three performance characteristics of a nursing unit discussed in the first section (i.e. the effectiveness in providing nursing care, the efficiency of a nursing unit and the job satisfaction of the nursing staff). The operational quality can be used in the development of the nurse scheduling support system, the use of this system

and the task performance of nurse scheduling, and will therefore possibly result in nursing schedules that positively influence the performance of a nursing unit. Research that operationalizes the quality concept of nursing schedules in such a way has not yet been conducted, mainly because most research on nurse scheduling focuses too much on solving the nurse scheduling problem according to one or two views on nurse scheduling quality discussed in the previous section. This limited focus is probably a result of the difficulty in solving the nurse scheduling problem. The following subsection describes why it is difficult to develop this type of nurse scheduling support system.

Figure 1.6 CYCLE OF DEVELOPING DECISION SUPPORT



1.3.3 Difficulty in solving the nurse scheduling problem

A nurse scheduling support system is a specific type of decision support system. An important part of a decision support system is its model base (Bonczek, Holsapple & Whinston, 1981). In general, a decision support system's model base is developed in four phases (see Sol, 1982; Verbraeck, 1991, p. 18; De Jong, 1992, p. 12). Firstly, the problem as perceived in reality (P_r) is translated into a model of this problem (P_m). Next, a solution to this modelled problem is computed (S_m). Then, this solution to the model is translated into the real situation (S_r). Finally, this solution in reality is applied to the problem as perceived in reality (P_r). Figure 1.6 shows these four phases.

However, in the case of a nurse scheduling support system, it is very difficult to develop its model base (Smith & Wiggins, 1977). Nurse scheduling presents a difficult problem to model and solve (see Okada & Okada, 1988). This problem is hard to solve for three main reasons, which are the complex data structure, the large number of possible solutions and the large number of constraints. The first reason disturbs the translation of the problem as perceived in reality into a model of this problem, while the last two reasons disturb a computation of a solution of the modelled problem. Below, these three reasons are discussed in more detail.

The nurse scheduling problem is hard to solve because of its complex data structure containing all kinds of employee information and schedule data (Courbon & Esaki, 1992). Several skill categories (e.g. registered nurses, licensed practical nurses and nursing assistants) are utilized to provide the blend of talents necessary

for patient care. The blend of talents required can vary on a unit from shift to shift, depending upon the medical treatments typically provided (Smith & Wiggins, 1977).

A second reason for the difficulty in solving the nurse scheduling problem is the very large number of possible nursing schedules combined with the lack of an efficient search algorithm. This can be illustrated by calculating the number of possible nursing schedules for a fictitious nursing unit, called East-5. At the East-5 nursing unit, a nursing schedule is arranged every four weeks. Each twenty-four hours, East-5 needs two nurses on the night shift, three nurses on the evening shift, and five nurses on the day shift. On the basis of these daily staff requirements, the total number of possible shift assignments for one (natural) day of the schedule period is 2.883×10^9 . The nursing schedule for the East-5 unit contains four weeks of seven days, which makes twenty-eight days. Therefore, the number of possible nursing schedules for this nursing unit is $(2.883 \times 10^9)^{28} = 7.510 \times 10^{264}$.

A third reason for the difficulty in solving the nurse scheduling problem concerns the large number of complicated constraints. For example, the labor contract between the hospital and the nurse can place a variety of restrictions on the types of schedules the nurse can perform (Rosenbloom & Goertzen, 1987, p. 19). The large number of complicated constraints cannot easily be applied to limit the space of acceptable solutions (Smith & Wiggins, 1977; Weil et al., 1995). These constraints concern, for example, continuity in service, personnel policies, staff preferences, operating budgets and labor constraints (see Rosenbloom & Goertzen, 1987). Additionally, some of these considerations may be in conflict with others, such as employment requests and the need to balance the workload (Randhawa & Sitompul, 1993). Also Ozkarahan and Bailey (1988, p. 306) stress the conflicting objectives and constraints of the nurse scheduling problem.

As described above, much research has been conducted to support the performance of the nurse scheduling task by means of a nurse scheduling support system. However, as the next chapter will describe, most of these systems (implicitly) focus too much on one or two views on nursing schedule quality discussed in the previous section. The quest for an operational quality concept remains unanswered so far.

1.4 PRELIMINARY RESEARCH QUESTIONS

This study aims to operationalize the concept of nursing schedule quality in such a way that it can cope with the pluriform nature of nursing schedule quality. This operationalization requires three steps. Firstly, the concept of nursing schedule quality needs to be (qualitatively) analyzed in such a way that all views on this quality are taken into account. This type of an analysis results in a conceptual model of nursing schedule quality. The second step concerns the operationalization of this conceptual model into a formal model of nursing schedule quality. This type of formal model enables the measurement of this quality. The objective of the third

step is the application of this formal model in order to support the task of nurse scheduling.

On the basis of these three steps, this study intends to investigate three preliminary research questions:

1. How can the concept of nursing schedule quality be analyzed?
2. How can the conceptual model of nursing schedule quality be operationalized?
3. How can the formal model of nursing schedule quality be applied in order to effectively support the task of nurse scheduling?

If the first two research questions can be answered, this will result in formalized quality criteria to assess nursing schedules. Answering the third question will result in an application of these criteria.

1.5 THESIS OUTLINE

In short, this study tries to analyze, operationalize and apply nursing schedule quality. This thesis describes the design, empirical results and conclusions of these three steps. The next chapter describes the theoretical background of this study. It compares a number of approaches to supporting nurse scheduling. The results of this comparison will show the necessity of a new approach. The third chapter describes the methodological foundation of this study, which is designed to investigate this new approach. The research results of this study are described in chapters four to seven. The eighth and final chapter of this thesis describes the conclusions of this study. Figure 1.7 shows this thesis outline.

Figure 1.7 STRUCTURE OF THIS THESIS

