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Nursing workload measurement as management information

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Abstract: Goal of the study presented in this paper was to balance the supply and demand of nursing care at nursing units within general hospitals. A 'management control framework' is developed, containing the relevant decision levels, the goal variable and the information needed to control the balance between supply and demand. A nursing workload measurement instrument is introduced, and an experiment is set up to test the performance of the framework and the measurement system in the daily practice of eight nursing units in two hospitals, during 20 consecutive weeks. Intervention has taken place in both the staffing and patient planning processes. The effects upon the goal variable has been measured. The variation coefficient of the work pressure is used as an indicator for the stability of the balance. The results of the experiment are presented.

Keywords: Health services, personnel, measurement, scheduling

1. Introduction

A few years ago a system of budgeting was introduced in Dutch hospitals. The Dutch National Hospital Board and the National Consultants Union together published a declaration of intent regarding the budgeting situation. Some important points are:

- cost budgets and activities have to be completely matched, being the collective responsibility of medical staff and management;
- a medical plan contains the expected activities;
- a hospital plan contains an indication of costs (manpower, materials);
- each department makes its own plan of activities, based on the agreed production; total costs, and not total activities, are set to an absolute limit.

The department managers are responsible for their budgets, but they cannot influence all costs; only direct costs. So indirect costs and overheads are not considered here. Relevant costs are for required staff, for equipment and instruments, and for materials used. Of these, the required staff is the most complex to determine. From the cost point of view, staff is also very important, because it is the most expensive production factor in the hospital's operating costs. So it is essential for the management to have insight into staff requirements. Workload measurement systems help to give this insight.

Does a workload measurement system by definition provide useful *management information*? It presumes to support the manager in taking his decisions, in this case decisions regarding the staffing process. The staffing process consists of several hierarchical levels. Each level has its own decision maker with specific competence to intervene, specific objectives and output, different time horizons and constraints. In my opinion, a management control system can only be successful as far as the inputs can be assigned. Output measure-

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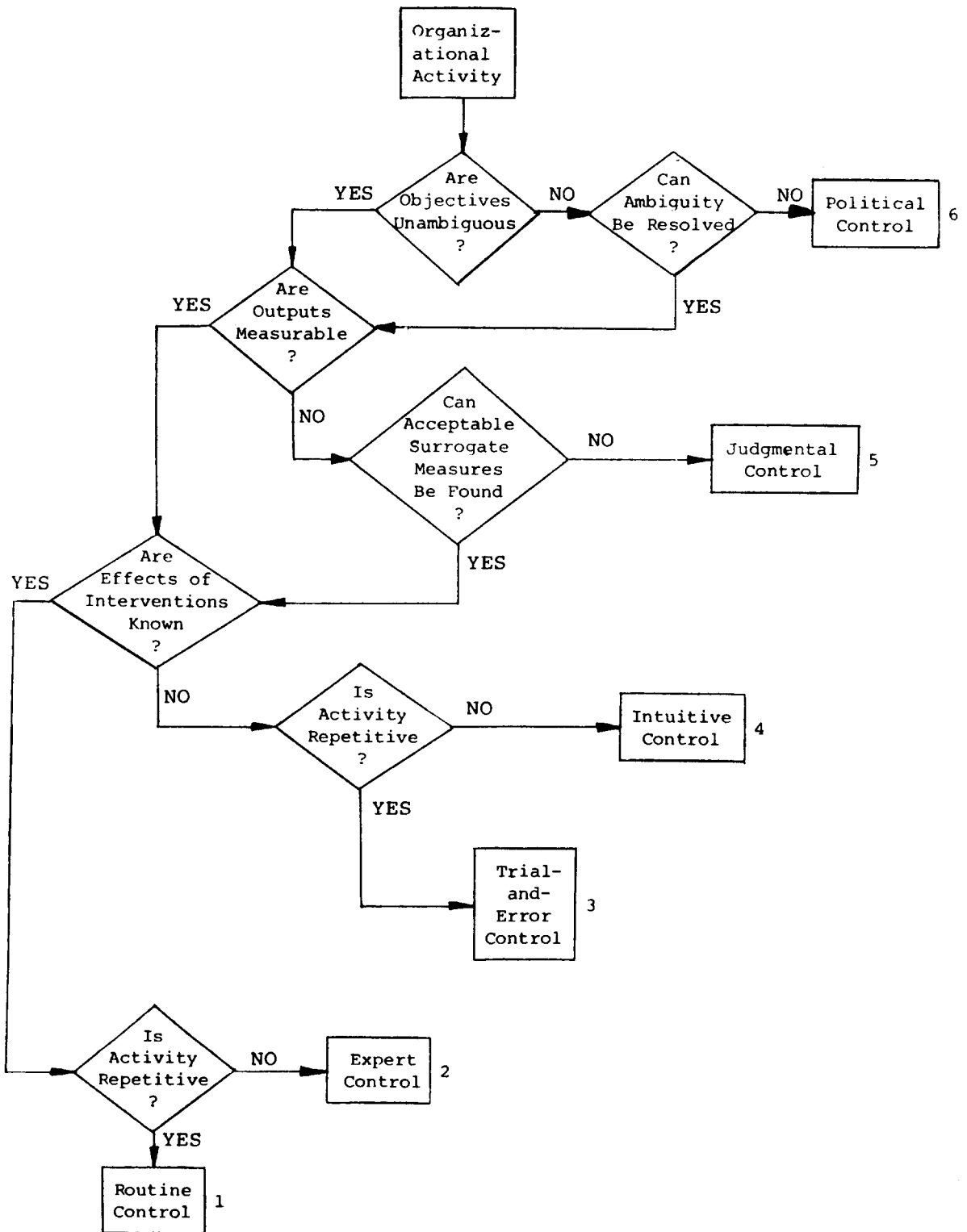


Figure 1. A typology for management control

ment, or workload measurement, provides useful management information when helpful in assigning inputs. In production control systems we often see a three-level decision hierarchy:

1. capacities are assigned to units/departments,
2. the use of capacities is scheduled in time,
3. corrective actions are applied to adjust the supply-demand ratio.

These levels correspond to the three time-horizons long, medium and short term and are often called strategic, tactical and operational decision level. A similar analysis of the staffing process is presented by several authors (Warner, 1976; Hershey et al., 1981). The process can be conceptualised with three levels: manpower planning, shift scheduling and manpower allocation.

Now the corresponding information needed can be formulated:

1. expected patient-mix for next year, by unit,
2. standards for capacity utilisation, forecast of the resulting capacity utilisation,
3. the actual capacity utilisation.

The declaration of intent mentions the matching of activities and cost as a goal of budgetting. Since activities are resulting from the demand of care and cost are incurred to supply the required care, we can formulate a management goal to balance the supply and demand of care at allowed costs. In this way, the actual capacity utilisation can be seen as an operational goal variable. With 'capacity' interpreted as 'staff', a definition is given:

actual capacity utilisation

$$= \frac{\text{actual workload per unit (hours)}}{\text{available staff per unit (hours)}}$$

Now we can try to develop a management control system, directed to the actual staff-workload ratio. Hofstede (1980) presented a typology for management control for several conditions (Figure 1). I use this as a reference and find the valid type by answering the following questions:

- Are objectives unambiguous? Yes.
 - Are output measurable? No.
 - Can acceptable surrogate measures be found? Yes (that is, some workload measurement system).
 - Are effects of interventions known? No (not yet...).
 - Is activity repetitive? Yes.
- control type: Trial and Error Control.

From this deduction the staffing process and capacity allocation can be controlled, that is, by trial and error and under the condition that some workload measurement system is available. If we succeed in knowing the effects of intervention, the routine control type can be considered. For the further approach I go back to the formulated information needs. The longer the period to which the information refers, the more vague and uncertain it will be. It is obvious to start at the lowest operational level: the actual workload, and from that the actual capacity utilisation. For the next higher information level, standards are required for supporting the medium term scheduling. Exceeding these standards in the actual situation requires corrective actions. Unfortunately, we don't have these kinds of standards. But there is a way to develop them. Corrective actions are taken now, when the staff-workload ratio is out of balance, I suppose. By observing the actual ratio at the moment that it happens, admissible combinations of workload and staff requirements might become clear, by trial and error (the considered control type!). It can lead to what I call a WL/SR-model (workload/staff requirements), that contains those combinations and their range. Once the model is developed, it is a guide-line for all decision levels, or, with a familiar name, a decision support model.

Figure 2, "A management control framework for nurse staffing and patient planning" (de Vries, 1981) is based on the same principles mentioned so far, i.e.

- to meet the standards of capacity utilisation is the goal variable;
- a supporting model containing these standards is developed;
- the information system takes a central place.

The framework presented at the time was mainly a theoretical exercise. It was elaborated to balance the supply and demand of nursing care at nursing units within a general hospital. My intention was to test it in practice by:

- choosing (or developing) a workload measurement system;
- setting up an experiment to test the performance of the framework and the measurement system in daily practice;
- executing the experiment, which means intervening in the planning processes and measuring the effects upon the goal variable.

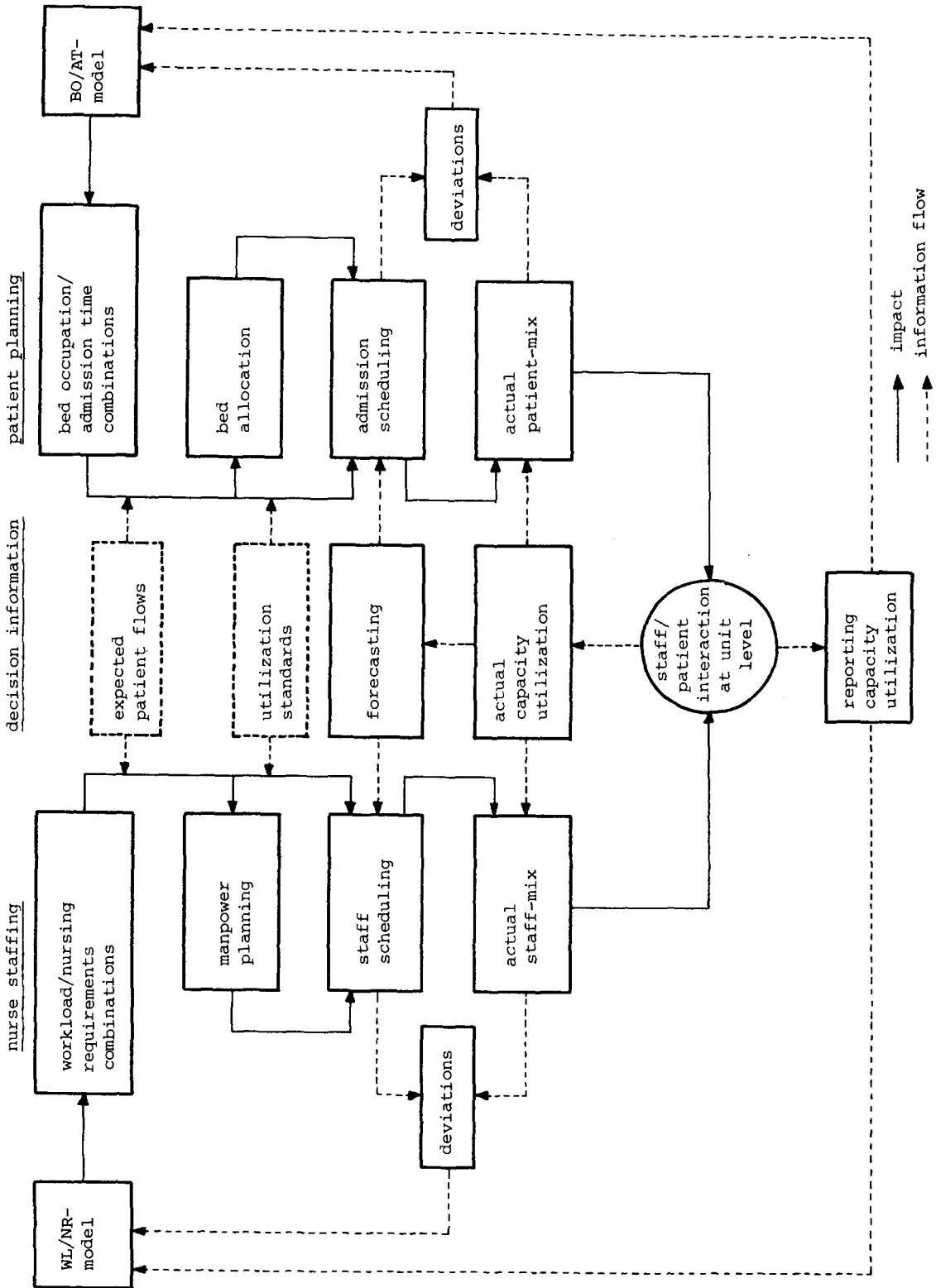


Figure 2. A management control framework for nurse staffing and patient planning

In the following sections I will present a summary of the study with some results.

2. Measuring the nursing workload

We need a measurement instrument to relate the required nursing staff and the available nursing staff. Numerous patient classification systems have been developed, more than one thousand in the United States alone (Giovanetti, 1972). Generally they are variants on some basic systems, such as those of Connor (1960), Barr (Oxford Regional Health Board, 1967) and Wolfe and Young (1965). Patients are classified according to their need for nursing care, such as low, medium and high care. Each category has a coefficient to determine total staff need.

The holding criteria in developing the systems are not quite clear, and in general are not mentioned explicitly. Implicitly they can be derived; as such can be mentioned:

- completeness; all aspects of nursing care are taken into consideration;
- accuracy; staff requirements must be determined exactly;
- universality; the system must be applicable to all kind of nursing units.

Under my study I have formulated my own criteria. Not measuring what can be measured, but only measuring to get the information supporting the decision making. As such can be mentioned:

- quantifying the need for care for long, medium and short term;
- giving insight in workload patterns and in differences between units;
- an instrument for staffing and matching workload and staff.

Besides this information aspect, I mention the following relevant criteria:

- friendliness, important for the daily use of the instrument;
- planning; the object of planning, the required staff, must be determined in advance; the smallest shift defines the required accuracy (usually a 4-hours period);
- efficiency; costs of implementation must be worthwhile;
- methodological aspects, such as validity and reliability.

In more recent studies it is stated that the

results of classification and observation studies should not be the only measure for staffing. Telford (1979) argues that no method is perfect, but a professional judgment, not being a subjective guess, must be decisive. There is a tendency that the classification system itself is rather indifferent, but the classification results must be related to the staff's judgment and to a quality assessment (for illustration: Kelly and Montgomery, 1982; Goldstone and Collier, 1982).

No attempt was made to develop a new workload measurement system, since more than one thousand of them already exist. Based upon my own criteria and the tendencies just mentioned, a selection was made. I have chosen the system that was developed at the San Joaquin General Hospital, Stockton, California (Murphy et al., 1978) and have made some adjustments for a better fit to my criteria. I will describe some characteristics only very briefly here.

Each patient is classified into one of four categories, i.e. self-care, medium, high and intensive care. There are nine indicators, such as independence, need for help with bathing and/or feeding, need for observation, which determine the patient category. By sampling and observation studies, for each category a coefficient is determined for the corresponding staff need. By daily classifying the patient mix and multiplying the number per category with the determined coefficients, the workload is assessed (in nursing hours, or full-time equivalents). A measure for the staff capacity utilisation can be obtained by relating the assessed workload to the available staff. The ratio of these variables I call 'work pressure', which is 100% in case of balance between supply and demand of nursing care.

These items relate to the objective element of the system. There is a subjective one too. The coefficients result from sampling and observation studies, but only those days are taken into consideration with an acceptable work pressure, according to the staff's judgment. In this way acceptable coefficients are found, based upon a normal work situation and a sufficient quality of care. The subjective element can also be of help in setting the standards, which we intended to develop by trial and error. The work pressure daily can be determined by objective classification, and by asking a subjective evaluation about the work pressure. If both assessments are made during a longer

period, this can lead to insight in acceptable combinations of workload and required staff. Also the effects of interventions in staffing and/or patient planning will become clear, both for the objective and the subjective work pressure. And indeed, by trial and error, a decision support model is developed.

3. Designing the experiment

Experiments were performed in two general hospitals. The intention was to test the performance of the framework and the measurement system in daily practice. Each hospital participated with four nursing units, two surgical and two medical units, during a period of twenty weeks. The ultimate goal, as mentioned before, was to balance the supply and demand of nursing care. In the previous paragraph this is made operational by measuring the work pressure. It is not just the value of this variable that matters, but especially its progress in time. What we want to avoid is the well-known symptom of running into extremes. Nursing units benefit by stability and calm. The variation coefficient (v.c.) of the work pressure can be used as an indicator of this stability. The v.c. is defined as standard deviation divided by mean. The more stable the behaviour of a variable over a certain period, the lower the v.c. The whole period was divided into five periods of four week each. For each period an evaluation was done by measuring the mean, standard deviation and v.c. of the work pressure, which was assessed in both an objective and a subjective way.

In the first four weeks the classification system was implemented and observation studies were done to determine the coefficients per category. For the work sampling, two units of the same specialism were considered as one cluster. We then had two hospitals with two clusters each, so sampling and the determination of coefficients were done four times separately, each during five week-days. Sampling was not done during weekend and during evening and night shifts, since required staff during these shifts does not depend on the measured workload, but on a minimum staff presence requirement. Knowing coefficients should play no role in staff allocation so there is no need for sampling.

After the first 4-week period, the behaviour of

work pressure was determined for each nursing unit. Then each pair of nursing units was split up in an experimental unit and a control unit. In the next three periods intervention in the planning processes took place in the experimental units only. Elements of control were introduced in order to improve the stability and to keep it at an acceptable level, again measured by the mean and v.c. of the work pressure.

Elements of controlling the goal variable are:

- predictability of the workload;
- improving the shift scheduling;
- predictability of the date of dismissal;
- improving the admission planning;
- taking measures for short-term adjustments;
- refining the decision support model, containing the standards for the value and range of the work pressure.

In the fifth and last 4-week period, intervention was stopped again and the measuring was continued in both the experimental and the control units in the same way. By setting up the experiment this way, a double comparison was allowed:

- the performance of the experimental units can be compared with that of the first period (diachronous);
- a (synchronous) comparison can be made between the experimental unit and the twin-unit, where intervention did not take place.

Properly it was not one single, well defined experiment that was executed, but a plural experiment testing the performance of the management control framework, of the measurement instrument, and the influence of a researcher on an on-going concern. And because this was not a laboratory situation, it will not be possible to ascribe some improvement to a specific intervention.

4. Some experimental results

Eight nursing units have participated in the experiment, counting about 280 beds. The measurements were done on each unit during 20 consecutive weeks. More than 30 000 patients have been classified. As background information the f.t.e. coefficients (full time equivalent) for the patient categories, determined by sampling studies were as shown in Table 1.

A cat. 4 patient occurs only incidentally on a

Table 1

	Cat. 1	Cat. 2	Cat. 3
Hospital A, medical cluster	0.14	0.24	0.42
surgical cluster	0.15	0.21	0.41
Hospital B, medical cluster	0.12	0.31	0.55
surgical cluster	0.14	0.20	0.42

'normal' nursing unit and is then set arbitrarily to an f.t.e. value of 1.0. With these coefficients, the required staff can be determined directly when the patients have been classified, by multiplying the number per category with the corresponding coefficient. All nursing activities, the patient related as well as all other activities to be done, are included in the coefficients.

First some general findings regarding all units and observations during the whole 20-weeks period are discussed. It was thought that the workload and the available staff were not well matched, certainly not on day to day basis. This hypothesis is fully confirmed by the study, for all units. During the whole period, the (Pearson) correlation coefficient between these two variables in all cases was less than 0.35. Another consequence of this is that the work pressure is less stable than workload or available staff. There appeared to be a significant ranking in several factors in the degree of stability:

1. the number of patients (the most stable),
2. the workload, measured by classification,
3. the subjective evaluation of work pressure,
4. the available staff (day shifts), and
5. the work pressure (the least stable).

This indicates that more attention must be given to the quality of shift scheduling, which now fairly contributes to instability. Daily, the subjective judgment regarding the work pressure is registered for day, evening and night shift. This judgment can be related to other variables, such as:

1. the number of patients on the unit,
2. the workload, quantified by classification,
3. the number of shifts available,
4. the number of staff hours available,
5. the ratio between 1. and 3. (which can be assessed without a workload measurement system), and
6. the work pressure, which is the ratio between 2. and 4.

The relationship was investigated by determining the correlation coefficients. For the day shifts,

the subjective evaluation appears to have the highest correlation with the workload (hospital A) and with the work pressure (hospital B, with explainable exception of one unit). The value of the coefficients for the several units was about 0.65. This leads to the general conclusion that using a refined measurement instrument for the workload yields insight into subjective experience and to the explanation of fluctuations in it.

The correlation coefficient mentioned here is a singular one, between subjective evaluation and objective work pressure, with no account of the composition of staff mix. Also a multiple correlation coefficient can be determined, by distinguishing staff mix into pupils, auxiliaries and qualified nurses. There appears to be only a slight increase, compared to the singular coefficient.

For the evening and night shifts, the situation is different. Correlations are much lower here. This is not unexpected, because the subjective evaluation itself is very stable during these shifts, and generally at a satisfactory level. The subjective pressure is not determined by fluctuations in workload, but merely by incidents which can not be controlled. This confirms my earlier view that there is little point in sampling studies of evening and night.

Before presenting some more detailed results, it must be stated that only in a few cases it has been possible to improve the stability within 20 weeks. In the other cases it has become clear, why success failed to appear and also which conditions have to be fulfilled for the application of the control system. The experiment in hospital B was more successful than hospital A. Some relevant differences between the two hospitals are:

- I asked hospital A to participate in my experiment;
- hospital B asked me if they could participate in an experiment in order to perform workload measurements and improve stability;
- the experiment in hospital B started a few months after the one in hospital A, so we could profit by earlier experience;
- in hospital B, the project was guided by a steering committee, with representatives of the relevant sections in the organisation; this facilitated the intervention in the staff and patient planning processes.

The designed management control framework contains a feed-forward loop to the scheduling

level, based upon a forecasting of the expected workload, and by that of the work pressure. The predictability of the workload has been investigated. This was not done by forecasting the pattern of care for some dozens or hundreds of predefined diagnosis groups. The approach here

was to use the expert knowledge of the nurses, and ask them to forecast a few days in advance the workload, based upon the actual patient mix, and the expected dismissals and new admissions.

For the medical units, forecasting proved to be difficult. However, the forecasting error of the

32-beds surgical unit, first and last test-period

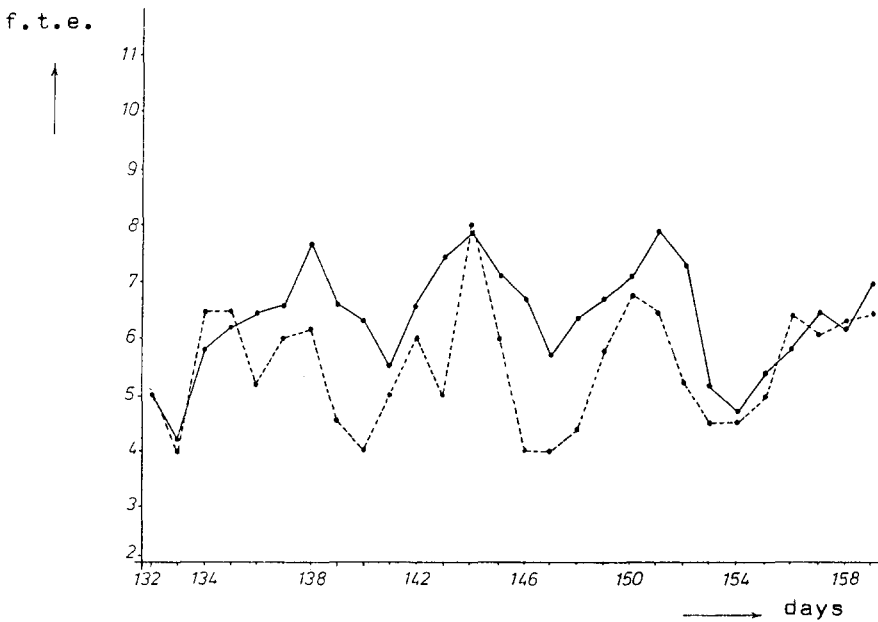
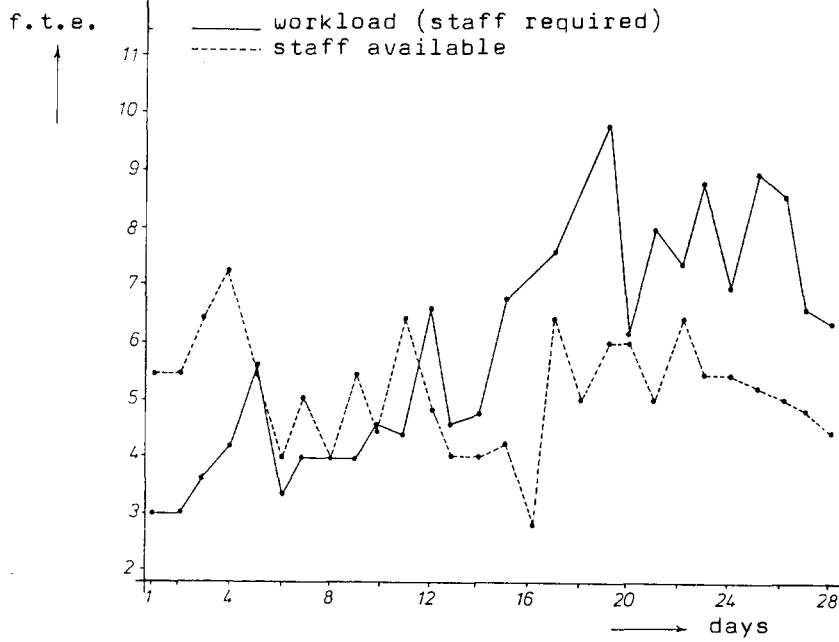


Figure 3. The course of workload and available staff (start of the experiment: above; end of the experiment: below)

Table 2
Improvement of stability in hospital B (variation coefficient of work pressure)

Medical – objective:	0.33 → 0.17
– subjective:	0.43 → 0.17
Surgical – objective:	0.39 → 0.15
– subjective:	0.34 → 0.15

workload one day in advance was less than a half f.t.e. in 88% of the cases, referring to a unit-part of 18 beds. The best strategy here seems to be a shift scheduling system that meets the average staff requirements, and taking additional measures for short term adjustments, if necessary. This implies feedback rather than feedforward control, but feedforward is not adequate when forecasting is problematic. For the surgical units, results were remarkable; in hospital A even better than in hospital B. For a 16-bed unit-part, the forecasting error one day in advance was less than a half f.t.e. in 82% of the cases, and two days in advance this was 67%. During the experiment the forecasting could be further improved when the nursing staff got insight in the waiting list for patients to be admitted for a surgical operation. Moreover, the stability could be improved by giving the nursing staff the possibility to influence the admission planning.

The variation coefficient of the work pressure is used as indicator for the stability of the balance between supply and demand of nursing care. The results for hospital B are given in Table 2. For the medical units there was a strong improvement for the experimental unit during twenty weeks, while at the control unit there was a slight deterioration. For the surgical units there was an improvement for both units, but strongly for the experimental one and slightly for the test one.

For illustration, the course of workload and available staff is represented in a graph, one at the start and one at the end of the experiment (Figure 3).

5. General conclusions

Feedforward control is preferred to feedback control, because feedback is not activated until the situation is out of balance and an adjustment is

required. However, feedforward is not adequate when forecasting is problematic. In that case management must have tools for the short term adjustment of available staff (such as nurses from a floating pool or from a temporary staff agency) and/or adjustment of the admission planning or surgery program.

Standards can be developed to relate the workload to the corresponding staff requirements. There appears to be not a single point of balance between supply and demand, but a range; for example a work pressure between 85% and 125% proved to be acceptable in most cases. It is the first responsibility of the unit manager to assess whether there is a balance or a need for corrective actions.

The characteristics of the control system are:

- coefficients for the staff requirements by patient category are determined for each unit separately;
- the professional judgment of the unit nurses regarding the work pressure and the quality of rendered care plays an important role;
- the expert knowledge on the shop floor is used in forecasting the patients' workload.

Finally I return to the title of this paper and make some remarks regarding the theme: nursing workload measurement as management information.

1. Uniform staffing criteria can be handled for all units in the hospital.

2. Differences in workload between units can be registered, both for the short and the long (structural) term.

3. A mechanism of coordination between (clusters of) units can be created regarding under- or overstaffing.

4. Day-to-day fluctuations in workload can be registered and, moreover, can be anticipated by forecasting.

5. Differences between units can be pointed out regarding the subjective experience of work pressure and its elasticity.

6. The consequences of the proposed admission scheduling can be determined rather exactly, at least for surgical patients.

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