Multi-Level Nurse Rostering Problem in Hemodialysis Service

As shown in Fig.1, it is assumed that a group of nurses at different levels in a rostering period and demand which includes the number of nurses of each role in each shift and the level requirements are known. The demand is obtained by patient scheduling. A feasible and reasonable nurse roster that satisfies a series of constraints should be made with the goal of scheduling nurses in different levels reasonably and satisfying the shift and role preference of nurses. Nurse rostering should determine the work shifts of nurses and the roles in these shifts.

There are often two shifts every day in hemodialysis service, shift A (in the morning), and shift P (in the afternoon). Hemodialysis service must be provided by the cooperation of in-charged nurse, dispensing nurse, and treatment nurse. The in-charged nurses are responsible for coordinating the work of the shift. The treatment nurses are responsible for operating the dialysis machine and related work, and the dispensing nurses are responsible for dispensing and related work. The required levels of qualification of different nurse roles are different. The nurses in hemodialysis service are classified into three levels, from lv1 to lv3 in which lv3 is the highest level. The nurses at higher level can replace the nurses at lower level, but not vice versa. The level of a nurse who is qualified for one nurse role should be not lower than the required level of the role. The required level of in-charged nurse is lv2 and the required levels of dispensing nurse and treatment nurse are both lv1.

With a thorough investigation made in Hemodialysis Service Center P in Wuhan, China, the managers care much about how to assign nurses in different levels and improving the nurse job satisfaction. First, allocation of nurses in lv2 and lv3 of shift A and shift P on a day should be balanced because nurses in lv2 and lv3 are good at emergency. Squared weighting method are used to synthesize the difference of the allocation of nurses in lv2 and lv3, and the weighting coefficients are set based on the reviews from managers. Second, the cost of a nurse in lv2 is lower than that in lv3, and nurses in lv2 are more skilled than those in lv1. Therefore, the proportion of nurse in lv2 in a shift should be improved. Third, meet the shift and role preference of nurses can effectively improve the nurse job satisfaction.

In a rostering period, a roster which includes the work arrangement of n nurses can be shown with a two-dimension table as shown in Table 1. Each line corresponds to the work arrangement of each nurse in a rostering period. The work arrangement on one day of each nurse is represented with a 2-tuple (p, q). p represents the work shift of the nurse and q represents the role in this shift. When p equals 1, it means shift A, p=2 shift P, and p=0 rest. When q equals 1, it represents the in-charged nurse, q=2 the treatment nurse, q=3 the dispensing nurse, and q=0 rest. For example, (0,0) represents that this nurse takes a rest, and (1,2) represents that this nurse works on the treatment nurse in shift A.
Fig. 1. Multi-level Nurse Rostering Problem in Hemodialysis Service. Top-down, the nurses are assigned to each shift and role. Two tuple \((1, lv2)\) in the box of in-charged nurse means that the number of required in-charged nurses in shift A on day \(t\) is 1 and the level requirement is \(lv2\). The others in the demands are the same. Bottom-up, the result of patient scheduling is service demand.

<table>
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<th>No. of nurse</th>
<th>MON</th>
<th>TUE</th>
<th>WED</th>
<th>THU</th>
<th>FRI</th>
<th>SAT</th>
<th>SUN</th>
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<td>((1,2))</td>
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<td>((1,3))</td>
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