STRATEGIES FOR CONSISTENT CARE IN SENIOR LIVING

A Thesis

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Master of Hospitality Administration

by

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ABSTRACT

This research is designed to provide systematic information about the consistent staffing problem in one nursing home, Cornell Manor, specifically the implementation of consistent staff assignment, and the potential influence of contextual factors on its implementation. It is focused on finding the best assignment of CNAs in households to improve consistency scores, with the objective being to assign as few different CNAs as possible to each unit. This study deals with a fixed workforce size with mixed contract types, full-time and part-time. It utilizes both optimization models and a comparison of assignment heuristic to develop CNAs scheduling decision making tools to find staff assignments that ensures consistent care. The findings include that too many part-time staff working too few shifts is the major cause of bringing up the consistency score. The heuristic policies this study developed also demonstrate their effectiveness using simulation experiments. Reducing the size of units and adding partial flexibility by reassigning CNAs at the beginning of shifts to their home unit are also found to improve consistency scores.

BIOGRAPHICAL SKETCH

Issy Tan is pursuing a Master's degree at the School of Hotel Administration at Cornell University with a concentration on Real Estate Financial Management, Operations Research and Management Science. She obtained two Bachelor's degrees in Tourism Management from the United Kingdom and China with First Class Honors and Certificate of Industrial Experience with Distinction.

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INTRODUCTION

With baby boomers aging, there will be a significant increase in the number of older people in the U.S. population. According to United States Census Bureau (2014), there will be more than 95 million Americans over age 65 by the year of 2060. Senior living communities will find it harder to attract and maintain quality workers because of this a corresponding increase in the demand for senior living staff. Many research on staff type and staffing ratios in nursing homes suggests that the quality of care for residents is associated the care provided by nursing staff (Bowers, Esmond, and Jacobson 2000; Castle 2008), and, in particular, provided by certified nursing assistants (CNAs; see Burgio, Engel, Hawkins, McCormick, & Scheve, 1990).

The Personnel Rostering Problem which usually involves creating a cyclic duty roster for nursing staff under many different constraints, is one of the most time-consuming planning tasks present in nursing home contexts. Yet, due to nursing homes' daily demand, requirements such as legal working time restrictions, and availability of full time and part time nurse aides and staffing policies requiring specific nurse-to-patient ratios, scheduling CNAs is an extremely complex task to perform. The planning is usually done by experienced senior nurses manually, making it more difficult to satisfy the aforementioned quality of care.

The two most common models of job assignment are rotating and consistent assignment (RA, and CA respectively). Given a set of shifts for each day of the planning period, RA considers members of the personnel as interchangeable: the personnel rotates by use of a predetermined schedule (e.g., weekly or monthly) until everyone has been assigned to each schedule, while CA involves consistently assigning individual CNAs to specific residents with the general goal of enhancing the continuity of care. The rotating planning strategy does not take into account the continuity of assignment and this restriction is problematic in the nursing home contexts where consistent care has shown to enhance supportive relationships and to be associated with the quality of care (Kim, Harrington, et al., 2009; Cabana and Jee, 2004).

Advancing Excellence, The American Health Care Association and Leading Age (now called National Nursing Home Quality Improvement Campaign, 2016) was started by a group of organizations representing nursing home consumers, care staff and managers, government agencies, and private foundations to enhance the cultural change in the nursing industry. It provides free access to Web-based tools to support implementation of consistent assignment, defined as no resident has more than 12 such caregivers over a calendar month for long-stay residents or over each half month for short-stay residents. Intuitively, this practice, whereby staff members are assigned to the same residents on most shifts, makes sense: As staff members come to know their residents better and develop stronger relationships with them, they not only may enjoy their jobs more but may be better able to enhance care and quality of life for residents. Given these potential benefits, Burgio and Louis D, (2004) believe that consistent assignment is viewed as superior to rotating assignment, an alternative staffing model that aims to distribute care burden more fairly among staff and ensure that workers are familiar with most residents.

This research is designed to provide systematic information about the consistent staffing problem in one nursing home, Cornell Manor, specifically the implementation of consistent staff assignment, and the potential influence of contextual factors on its implementation. It is focused on finding the best assignment of CNAs households to improve consistency scores, with the objective being to assign as few different CNAs as possible to each unit. This study deals with a fixed workforce size with mixed contract types, full-time and part-time. It utilizes both optimization models and a comparison of assignment heuristic to develop CNAs scheduling decision making tools to find staff assignments that ensures consistent care.

This dissertation is laid out as follows. A detailed literature review is presented in the next section. Then it reports the level of consistent staff assignment for individual units of Cornell Manor and considers the stability of consistent staff assignment within these units, followed by a detailed description of the model and method used to clarify potential barriers to and facilitators of consistent staff assignment. This paper utilizes hindsight analysis with optimization models to come up with the optimized results and compares these units' actual performance with optimization results to discover factors that affect the consistency. Thirdly, forward-looking staff policies are developed from the hindsight analysis, assigning available CNAs to their reference unit, while maintaining continuity of care. Then these analytical policies are tested on the following months to examine how much do they affect the consistency performance.

Two of the large-sized households were also split into two small units respectively and tested with the optimization model to examine the impact of the unit size on the consistency. Finally, it will report some qualitative discussions regarding effective staff scheduling approaches and the benefits and challenges of consistent staff assignment.

LITERATURE REVIEW

Continuity of care has different interpretations, according to Parker et al (2010). "Information continuity" emphasizes the need to ensure effective communication between nursing staff, while "longitudinal" continuity focus on the patient having interactions with as few staff as possible, i.e. staff having a more consistent assignment, whereby staff members, particularly CNAs, are assigned to the same residents on most shifts. It is increasingly viewed as a cornerstone of culture change in nursing homes and has been advocated as a premium model with various proven benefits, including improving the facility's quality of care and residents' quality of life while contributing to a more stable workforce (Bowers et al., 2014). Many quality initiatives have advocated consistent assignment (e.g., Advancing Excellence in America's Nursing Homes Campaign goals and objectives). State Quality Improvement Organizations (QIOs) have recommended that nursing homes use consistent assignment (e.g., Patient Safety Insights, 2011) as have advocates for culture change (Doty, Koren, & Sturla, 2008). In addition, states Offices of Health Facilities and Certification promote consistent resident assignment. Further, Castle found that consistent assignments have been found to decrease staff turnover in residential care environments (Castle, 2011), and Stone and colleagues (2017) determined that consistent assignments in home care workers increased job satisfaction and was associated with a lower intent to leave (Stone et al., 2017). Roberts, *et al* (2017) understand the quality of consistent assignments from a resident perspective and suggest that the length of time over which the number of CNAs remains stable, extent of overlap in staffing practices between adopters and nonadopters of consistent assignment, along with organization of teamwork may affect resident perspectives of quality. As such, given these potential benefits, consistent assignment is now widely viewed as superior to rotating assignment, an alternative staffing model that aims to distribute care burden more fairly among staff and ensure that workers are familiar with most residents.

While many literature studies have focused on proving the relationships between consistent assignment and quality of care, little attention is given to its implementation. Slaugh et al (2018) are the first to study the use of an "on-call" pool as an operational strategy to improve consistency. They further demonstrate that an on-call pool can reduce staffing costs due to absences by 24% while also (slightly) reducing the inconsistency level, or significantly reduce the inconsistency level without increasing costs. Four out of eight primary care medical homes participating in case studies that aim to understand barriers of operationalizing medical home standards, indicate that having many part-time providers presented scheduling challenges to ensure continuity of care for patients (Gurewich, Cabral and Sefton, 2016). Some researchers suggest that adoption of consistent staff assignment practices may be more difficult in smaller nursing homes with lower staffing ratios (see Castle & Banaszak-Holl, 1997; Teresi et al., 1993), whereas separation of the nursing home into small units may be able to facilitate it (Advancing Excellence in America's Nursing Homes, 2013). Lemke, S. *et al*. (2017) indicates a consistent finding that a critical first step to sustained implementation is defining separate neighborhoods into units with limited sizes so that residents could reasonably be cared for by 12 or fewer caregivers. Silvestro and Silvestro in their research in acute care settings (2008) claim that those with less flexible scheduling arrangements (e.g., fewer alternative work shifts) experience more challenges when implementing consistent staff assignment practices than settings that have more flexible arrangements. Chan and Sarhangian (2017) also prove that the partial flexibility introduced by reassigning servers at the beginning of shifts may reduce the expected cost of the system up to 50% in emergency departments.

In the research of home care staffing problems, most researchers address the nurse-patient assigning problem on a single day basis considering a given set of available nurses (see Mascolo et al.,2014, Cheng and Rich,1998). Although they allow good adaptation meaning more flexibility when scheduling, it is difficult to incorporate continuity of care, which is important for multiple reasons discussed before. To our best knowledge, in the home care context, only Steeg and Schröder (2007) examine routing and rostering decisions under consideration of continuity of care. They implement continuity of care as part of a multi-criteria objective function which seeks to minimize the number of different CNAs visiting a resident on a weekly basis.

However, creating the staff schedule from scratch or static information is not practical or feasible in any workplace. A schedule that is based on historical data and can be adapted from time to time is preferred, as operation in reality is stochastic. This study focuses on optimization models and heuristic to develop CNAs scheduling decision making tools to find staff assignments that ensure as much consistency as possible.

METHODS AND MODELS

To overcome measurement and self-report data limitations in prior research (Roberts, Nolet, & Bowers, 2015), this study used raw staffing data from assignment and scheduling sheets. However, the process was challenging. Due to the large volume and ambiguous notes, explanation and clarification during data entry were required. We utilized the hindsight optimization model in Slaugh and Scheller-Wolf's study (2019) to better understand nurse scheduling decisions, i.e., which CNA should work in which unit on each shift. The total number of shifts and each CNA work and the shifts he or she work (day, evening or night shift) remains unchanged. A detailed description including notations of the model is provided below.

μ: $the\ set\ of\ all\ units,$

S: $the\ set\ of\ all\ shifts\ over\ some\ time\ period\ (a\ month\ in\ this\ case),$

ω: $the\ set\ of\ all\ workers,$

x_{ijk}: $decision\ variable\ (x_{ijk}$

$$= 1\ refers\ to\ worker\ i\ works\ in\ unit\ j\ on\ shift\ k\ for\ i \in \omega, j \in \mu\ and\ k \in S, and\ 0\ otehrwise,$$

y_{ij}: $variable$ (y_{ij}

$= 1$ if $worker$ i $works$ at $least$ one $shift$ in $unit$ j $over$ the $time$ $horizon$),

A_{ijk}: $input$, the $actual$ $shift$ $schedules$ (A_{ijk}

$= 1$ $meaning$ $worker$ i $worked$ in $unit$ j on $shift$ k and 0 $otherwise$

The mathematical formulation for this problem can be stated as follows:

$$\min \sum_{i \in \mathcal{W}} \sum_{j \in \mathcal{U}} y_{ij}$$

subject to

$$\sum_{i \in \mathcal{W}} x_{ijk} = \sum_{i \in \mathcal{W}} A_{ijk} \qquad \forall j \in \mathcal{U}, k \in \mathcal{S} \tag{1}$$

$$\sum_{j \in \mathcal{U}} x_{ijk} = \sum_{j \in \mathcal{U}} A_{ijk} \qquad \forall i \in \mathcal{W}, k \in \mathcal{S} \tag{2}$$

$$\sum_{k \in \mathcal{S}} x_{ijk} <= M * y_{ij} \qquad \forall i \in \mathcal{W}, j \in \mathcal{U} \tag{3}$$

The three constraints listed above refers to the requirements discussed in the first paragraph of this chapter: the number of CNAs working in each unit on each shift stays the same as in the actual schedules, and the working schedule of each CNA is the same as that of in reality. The constant M in constraint 3 allows the yij variables to indicate whether CNAs work at least one shift in each of the units. And in order to minimize the disruptiveness of the work schedule for full-time CNAs in terms of their home units, a further constraint is added to ensure any CNA who worked at least 15 shifts in one unit in reality to work in that unit in the optimization result as well.

$$\sum_{k\epsilon s} x_{ijk} \geq \sum_{k\epsilon s} A_{ijk}\ 1\{\sum_{k\epsilon s} A_{ijk} \geq \widehat{N_1}\} \quad \forall\, I \in \omega, j \in u$$

where 1{·} represents the indicator function.

This study also developed scheduling policies based on where each CNA has worked during March to assign aides before the start of each shift and decide which unit should the worker go in April to see how that would affect the consistency.

Policy 1*: CNAs that worked the highest number of shifts in March have the priority to work in the unit where they have worked most frequently in March.*

Policy 2*: CNAs that worked the lowest number of shifts in March have the priority to work in the unit where they have worked most frequently in March.*

$A_{ijk}^{m}=\begin{cases} 1, if\ aide\ 1\ works\ in\ unit\ j\ on\ shift\ k \\ 0, otherwise \end{cases}$ *in March*

x_{ijk}*: decision variable, same set up as* A_{ijk}^{m}*, set to 0 by default*

r_{ik}: $priority\ score\ for\ aide\ i\ on\ shift\ k$

Whoever works the most shift in March:

Each aide i worked $\sum_{j\in u}\sum_{k\in S} A_{ijk}^{m}$*shifts in March;*

Sorting $\sum_{j\in u}\sum_{k\in S} A_{ijk}^{m}$*in a descending or ascending order;* $\mu \in \{A, P, W\}, k \in \{D, E, N\}$

Ties broken randomly:

Aide i's first choice in units is unit j(1) based on $\sum_{k\in S} A_{ijk}^{m}$*, if available,* x_{ijk}*=1; if first choice not available, go with second choice (or choose randomly).*

e.g. If unit j is open, $\sum_{i\in\omega} x_{ijk} < \sum_{j\in\omega} A_{ijk}$

RESULTS

The study first used 2018 May schedule as an example to examine the nursing home's consistency performance. In total, 1607 shifts worked in May were examined at Cornell Manor. The daily average staffing level, in other words, the number of staff who actually worked each shift in each of the three different units in May 2018, is shown in Table 1. As a consistent assignment is simply defined as the same caregivers caring for the same residents every time they are scheduled to work, it can be viewed as the number of different caregivers who work at least one shift over the course of a month.

Based on the staffing level, 14, 13 and 7 CNAs are needed for Unit P, Unit W and Unit A respectively to cover three different shifts. In May, 425, 449 and 157 shifts were actually worked in these three units. Therefore, by dividing the total number of shifts in a unit by the average number of shifts actually worked (i.e. average daily staffing levels) gets us the minimum number of CNAs to cover those shifts in three units. In other words, with an all full-time labor constitution, the facility could fill all schedules with 30 and 34 CNAs for Unit P and Unit W and 22 CNAs for Unit A.

Table 1. Average Daily Staffing Levels for May 2018

		Day	Evening	Night	Total
Unit P	Nurses	2	3	1	6
	CNAs	6	6	2	14
Unit W	Nurses	2	2	1	5
	CNAs	5	5	3	13
Unit A	Nurses	1	1	1	3

	CNAs	3	3	1	7
Total		19	20	9	48

Table 2. Minimum Number of CNAs to Cover All Shifts

	Day	Evening	Night	Total
Unit P	12	12	6	30
Unit W	13	13	8	34
Unit A	9	9	4	22

Using the Advancing Excellence Campaign's consistency of care metric, the number of different CNAs who worked at least one shift in each community unit over the course of one month is shown in Table 3. It is calculated using schedule data from March to May 2018, and only worked shifts were counted. No-shows, shifts canceled or called off were not factored into the consistency metric. Overall, there were on average 30, 75 and 78 different CNAs working at least one shift in these three months in unit A, unit P and unit W respectively. The best case scenario was unit A in May with only 24 different CNAs working in that month, while the worst case scenario was in March, unit W with 55 different CNAs working.

Table 3. Number of Different CNAs in Each Community (i.e., Consistency of Care Scores)

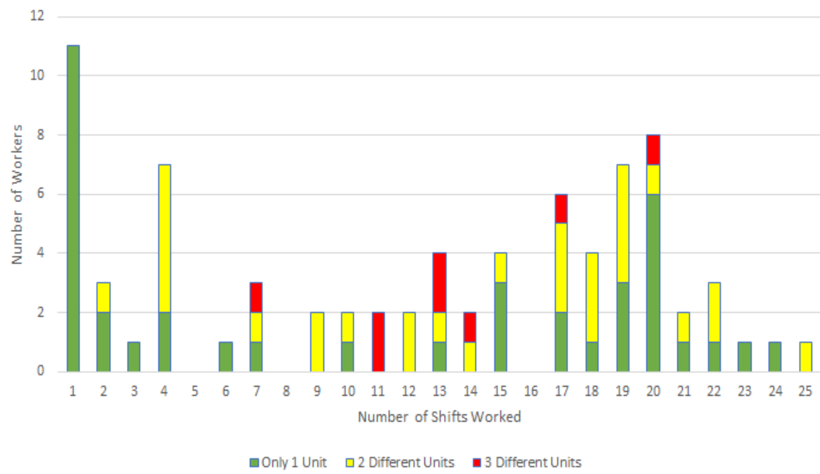
	March			April			May		
	Unit A	Unit P	Unit W	Unit A	Unit P	Unit W	Unit A	Unit P	Unit W
Day	9	27	25	7	25	23	8	35	28
Evening	9	29	32	5	34	30	12	29	30

Night	8	15	19	15	10	22	4	10	20
Consistency Score	23	52	55	26	49	54	21	52	54

It can be noticed that the consistency score is less than the sum of number of different CNAs working in three different shifts in one unit. The reason for this is one CNA may work across the day, evening and night shifts within the same community. For example, one CNA worked in day shifts in unit A might also work in evening shifts in unit A.

Table 3 shows that the actual results still nearly doubled the minimum scores for all three units reported in Table 2. One reason why this happened might be that some certain CNAs were assigned more consistently than others. Take May as an example, in total 80 CNAs worked at least one shift. The number of shifts that each worker worked in May is shown in Graph 1a. The number in the bottom is the number of shifts a worker worked, and whether they just worked in one unit, or 2 units, or all 3 units. For example, there was one worker who worked 24 shifts in May and they were all in the same unit. There were three workers who worked 7 shifts: one of them worked all seven shifts in 1 unit, one of them worked in 2 different units and one of them worked in 3 different units. We observe these clusters on the graph: one on the left is that there were 23 CNAs that worked in 4 or fewer shifts in May, and if we look at the middle group, these are the part time CNAs and we can see that the columns appear to be in yellow and red, which means these part time workers were not being scheduled in one unit, instead, they were working 2 or 3 units despite their small number of shifts.

Graph 1a. The Number of Shifts Worked in Different Units in May



Next, we also investigated how the day of the week and different shifts factored into the consistency when creating a schedule. It displays how frequently a CNA is working a shift in a household, where that shift is the only shift over the course of the month where a CNA works in that household. In other words, a CNA is working in a household where they have not worked any shifts before that month, and they will not work any shifts in that household for the rest of that month. These instances are going to drive up the consistency of care metric. The results are shown in Table 4. Not surprisingly, Friday and Saturday, and evening shifts on Monday have the most frequency of units ended up getting someone who made the only appearance in the entire month. Monday evening shifts are also difficult, with 4 instances that only worked one shift in that unit over the course of the month.

Table 4. The Frequency of CNAs that Work Only Once in a Unit in May

Shift	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Average
Day	0	0.25	0.4	0.2	0	0.75	0.5	0.30
Evening	0	1	0.2	0	0.4	0.25	0.75	0.37
Night	0	0	0.4	0	0.2	0.75	0.25	0.23

The number of shifts that were scheduled but did not work due to different reasons are calculated and displayed in Table 5. In total, 99 CNA scheduled shifts resulted in either cancellations, call-offs, or no-shows, which makes up 6.38% of the originally scheduled shifts. By comparing the consistency scores before these instances (shown in Table 6.) to the actual performance, it is noticed that there is not too much of a difference between the scheduled and actual consistency. It could be partly explained by the fact that 44 of 99 shifts were left unfilled, preventing the scores from going up. Additionally, the scheduler seemed to be able to find replacements from CNAs that were already working most of his or her shifts in that unit.

Table 5. Number of Cancellation, No-shows, etc.

Cancellation	Call-off	No-show	Cross-out	Total
31	27	13	28	99

Table 6. Scheduled, Actual and Ideal Consistency Scores

	Scheduled	Actual	Ideal
Unit A	19	21	12
Unit P	53	52	23
Unit W	52	54	21

Next, we utilized the optimization model built with the OpenSolver software to recreate a schedule while keeping the shifts worked by each CNA exactly the same. In other words, if a CNA worked three day shifts and one evening shifts in that month, he or she will work three day shifts and one evening shifts in the optimized results, but probably in different units. Other constraints include that CNAs that worked more than 15 shifts in one unit continue to work in that household. The objective of the model is to minimize the average number of different CNAs that work in each of the three units. The maximum solution times is 1,000 seconds, meaning the model will stop running after 1,000 seconds and provide a best result generated within this time frame. The results are displayed in the Table 7a and Table 7b below.

Table 7a. Optimized Consistency Scores for March

		Actual	Optimized
March	Unit A	23	18
	Unit P	52	46
	Unit W	55	47

Table 7b. Optimized Consistency Scores for April

		Actual	Optimized
April	Unit A	26	20
	Unit P	49	41

	Unit W	54	47

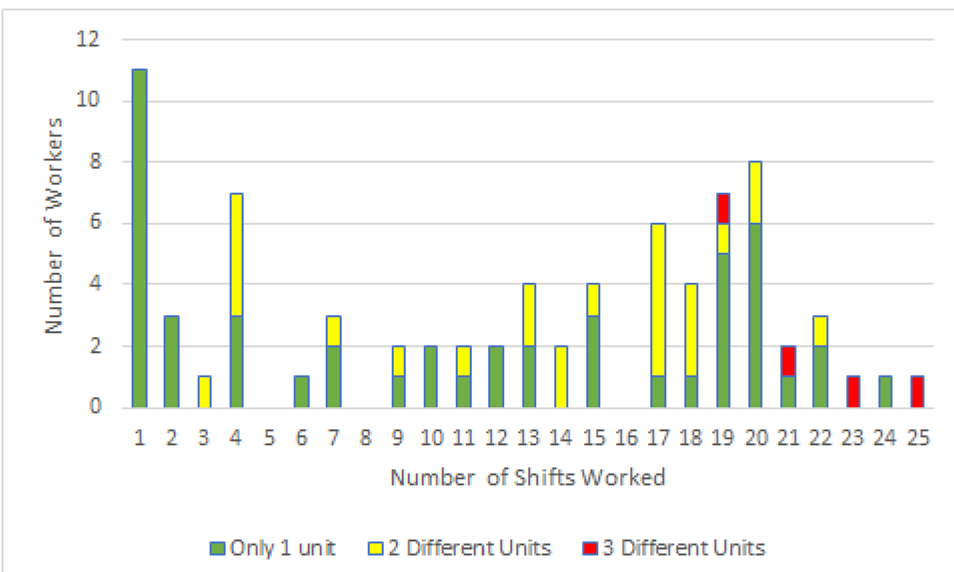
Table 7c. Optimized Consistency Scores for May

		Actual	Optimized
May	Unit A	21	26
	Unit P	52	38
	Unit W	54	51

As we can see from the table, with perfect hindsight for March, April and May, we could have improved consistency by an average of 20% (5.4 fewer CNAs) for the day, evening and night shifts. The number of different CNAs caring for residents in each unit ranged from 18 to 51 in one unit to 31. However, notably, the optimized consistency score for unit A in May is higher than the actual result. This could be the result of the significant improvement in unit P, leading to more CNAs ended up in unit A. Overall, average consistency across three units improved from 11.3 to 9.3, slightly more than 18% of the reduction. In the original schedule, we see many CNAs scattering their shifts they worked across many different units. In the optimized schedule, the number of CNAs who work across 2 or more than 2 different units greatly decreased over the entire month. One thing that can be noticed is that it might be helpful for some of the full-time CNAs to split their shifts across two different communities, adding some extent of flexibility to cover the shifts and avoid bringing the part-time aides.

Graph 1b shows the optimized distribution of shifts each CNA work and the number of different units where they work. Compared to Graph 1a where the actual schedule displays, the average number of different units where part-time CNAs (who worked total between five and fifteen shifts during that month)— is 1.36 different units, 0.56 shifts less than that of the actual schedule (1.92). For those full-time aides who work at least twenty shifts,the number is 1.61 different units, 0.13 shifts more than that of actual schedule (1.48). The average across the entire CNA workforce was 1.43 different units over 1.58 shifts.

Graph 1b. The Number of Shifts Worked in Different Units in May Optimized Result



We then developed scheduling policies based on where each CNA has worked during March to assign aides before the start of each shift and decide which unit should the worker go in April to see how that would affect the consistency. Results with two different policies are shown in Table 8a and Table 8b. With policy 1, which firstly assigns full-time staff at the start of each shift based on their home unit last month, we can see that the consistency score went down 3.8%, 8.2% and 7.4% for three units respectively. With policy 2, the number became 14.3% and 25.9% for two big units. It turns out that anchoring part-time workers to their home unit and having some flexibility allows for more consistent care. The number of shifts worked in different units under the two policies are shown in the Graph 2a and Graph 2b below. From the graphs, it is clear that under the part-time first policy, for those who worked less than 15 shifts, the number of different units they worked in significantly decreased, meaning part-time aides are now assigned more consistently than the full-time workers.

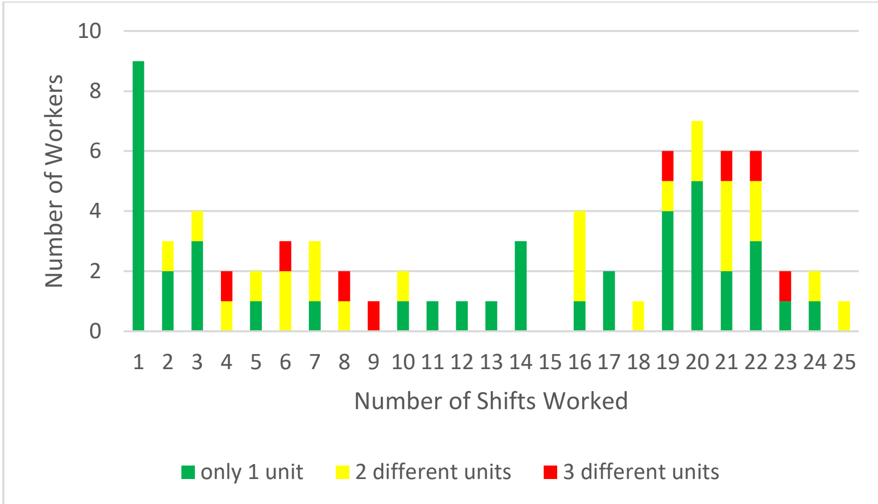
Table 8a. Consistency Scores under Policy 1

AW		PC		WS	
w/policy	actual	w/policy	actual	w/policy	actual
25	26	45	49	50	54

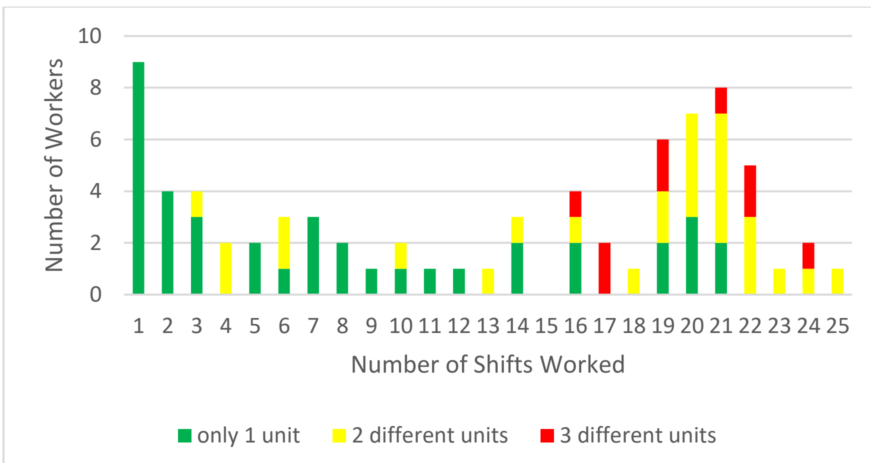
Table 8b. Consistency Scores under Policy 2

AW		PC		WS	
w/policy	actual	w/policy	actual	w/policy	actual
28	26	43	49	40	54

Graph 2a. The Number of Shifts Worked in Different Units in April Simulated Result under Policy 1



Graph 2b. The Number of Shifts Worked in Different Units in April Simulated Result under Policy 2



Lastly, the two big households, PC and WS were each split into two small units respectively based on the April schedule. The adjusted data (now with "five" units) were then tested with the optimization model and the results are shown in the table 9 below. As we can see that the average number of CNAs worked in the three units were improved by 7.7%, 16.7% and 25% for day, evening and night shifts respectively.

Table 9. Average number of different CNAs worked in five units for different shifts

	Original optimized score	Optimized score with split units
Day	13	12
Evening	18	15
Night	12	9

DISCUSSION AND CONCLUSION

One thing that's positive is that a significant number of CNAs are working across different shifts in one unit. That's the reason why when we add up the consistency scores for day, evening and night shift, it's actually less than the total consistency score in that household. Therefore, assigning CNAs for different shifts might help with the consistency performance. Also, night shifts on Thursday, Friday and Saturday have the most frequency of when most likely units ended up getting someone who made the only appearance in the entire month. Scheduling these times are difficult but having more full-time staff to cover these times rather than leaving them to one-offs can significantly improve the consistency of care. Cornell Manor also seems to handle call-offs well. The study did not dive deep into why these call-offs and cancellations occurred. One possible explanation could be Cornell Manor currently has feasible processes to find and assign CNAs that do not cause inconsistency of care to fill the shifts. From the actual schedule in May, we can see too many part-time staff working too few shifts seems to be the major cause of bringing up the consistency score. The heuristic policies this study developed demonstrate their effectiveness using simulation experiments. The partial flexibility introduced by reassigning CNAs at the beginning of shifts to their home unit can improve consistency scores. Therefore, tracking the communities where each CNA has worked allows opportunities to swap aides before the start of each shift, adding flexibility to the schedule, thus, to improve the consistency of care. This is consistent to the findings of Silvestro and Silvestro that those with more flexible scheduling arrangements experience less difficulty when implementing consistent staff assignment practices discussed previously in the Literature Review section. And it coincides indirectly with Chan and Sarhangian's study (2017) that reassigning servers at the beginning of shifts may reduce the expected cost of the scheduling system. By splitting large-sized neighborhoods into smaller units, the consistency scores for April improved for all three shifts, which is consistent to Lemke, S. *et al*. (2017)'s finding that a critical first step to sustained implementation is defining separate neighborhoods into units with limited sizes so that residents could reasonably be cared for by 12 or fewer caregivers.

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APPENDIX

MATLAB Codes Used to Develop Stochastic Policies

```
%%pick the name
[m,n] = size(April);
[p,q] = size(March);
AW=strings(20,30);PC=strings(20,30);WS=strings(20,30);
for date=1:1:30;
  %% Initialize
  A = strings(m,5);
  CounterName = 0;
  ColumA = 1;
  for c1=1:1:m
    if (April(c1,date+1) == '1'&&April(c1,1)~="Agape Way"&&April(c1,1)~="Peacock
    Court"&&April(c1,1)~="Wilbur Square")
      A(ColumA,1) = April(c1,1);
      ColumA = ColumA + 1;
      CounterName = CounterName + 1;
    end
  end
  B=strings(CounterName,8);
  if (CounterName>0)
    for c2 = 1:1:CounterName
      for c3 = 1:1:p
        if (March(c3,1) == A(c2,1))
        A(c2,2) = March(c3,2);
        A(c2,3) = March(c3,3);
        A(c2,3) = March(c3,3);
        A(c2,4) = March(c3,4);
        A(c2,5) = March(c3,5);
        end
      end
    end
  end
  for i=1:1:CounterName
    for j=1:1:5
             if
(A(i,j)==""
             )
 B(i,j)="0";
      else
        B(i,j)=A(i,j);
      end
    end
  end
  %%bubble sort
  tempB1="0";tempB2="0";tempB3="0";tempB4="0";tempB5 = "0";
  for c4=1:1:CounterName
    for c5=2:1:CounterName
      if (str2double(B(c5-1,5)) < str2double(B(c5 ,5)))
        tempB1 = B(c5-1,1); B(c5-1,1) = B(c5,1); B(c5 ,1)= tempB1;
        tempB2 = B(c5-1,2); B(c5-1,2) = B(c5,2); B(c5 ,2)= tempB2;
        tempB3 = B(c5-1,3); B(c5-1,3) = B(c5,3); B(c5 ,3)= tempB3;
        tempB4 = B(c5-1,4); B(c5-1,4) = B(c5,4); B(c5 ,4)= tempB4;
        tempB5 = B(c5-1,5); B(c5-1,5) = B(c5,5); B(c5 ,5)= tempB5;
      end
    end
  end
  %%   sort the
  unit
  tempa=0;tempb
  =0;tempc=0; for
  c6=1:1:Counter
  Name
    tempa=str2double(B(c6,2));
    tempb=str2double(B(c6,3));
    tempc=str2double(B(c6,4));
    if(tempa>=tempb&&tempb>=
    tempc) %% a>=b>=c
      if(tempa~=0)        B(c6,6)="Agape
      Way";   else   B(c6,6)=""   ;   end
      if(tempb~=0)      B(c6,7)="Peacock
```

```
Court";   else   B(c6,7)="";   end
if(tempc~=0)      B(c6,8)="Wilbur
Square";  else   B(c6,8)="";   end
continue
end
if(tempa>=tempc&&tempc>=tempb)
%%     a>=c>=b     if(tempa~=0)
B(c6,6)="Agape     Way";     else
B(c6,6)=""  ;  end  if(tempc~=0)
B(c6,7)="Wilbur   Square";   else
B(c6,7)="";    end   if(tempb~=0)
B(c6,8)="Peacock   Court";   else
B(c6,8)=""; end continue
end
if(tempb>=tempa&&tempa>=tempc)
%%     b>=a>=c     if(tempb~=0)
B(c6,6)="Peacock   Court";   else
B(c6,6)="";    end   if(tempa~=0)
B(c6,7)="Agape     Way";     else
B(c6,7)=""  ;  end  if(tempc~=0)
B(c6,8)="Wilbur   Square";   else
B(c6,8)=""; end continue
end
if(tempb>=tempc&&tempc>=tempa) %% b>=c>=a
  if(tempb~=0) B(c6,6)="Peacock Court"; else B(c6,6)=""; end
  if(tempc~=0) B(c6,7)="Wilbur Square"; else B(c6,7)=""; end
  if(tempa~=0) B(c6,8)="Agape Way"; else B(c6,8)=""        ; end
  continue
end
if(tempc>=tempa&&tempa>=tempb) %% c>=a>=b
  if(tempc~=0) B(c6,6)="Wilbur Square"; else B(c6,6)=""; end
  if(tempa~=0) B(c6,7)="Agape Way"; else B(c6,7)=""        ; end
  if(tempb~=0) B(c6,8)="Peacock Court"; else B(c6,8)=""; end
  continue
end
if(tempc>=tempb&&tempb>=tempa) %% c>=b>=a
  if(tempc~=0) B(c6,6)="Wilbur Square"; else B(c6,6)=""; end
  if(tempb~=0) B(c6,7)="Peacock Court"; else B(c6,7)=""; end
  if(tempa~=0) B(c6,8)="Agape Way"; else B(c6,8)=""        ; end
  continue
end
end
%%Modle of Arrangement
CounterAW=0;CounterPC=0;CounterWS=0;
TempCounterAW=0;TempCounterPC=0;TempCounterWS=0;
for c0=1:1:m
 if (April(c0,1)=="Agape Way")
   CounterAW=str2double(April(c0,date+1));
   continue;
 end
 if (April(c0,1)=="Peacock Court")
   CounterPC=str2double(April(c0,date+1));
   continue;
 end
 if (April(c0,1)=="Wilbur Square")
   CounterWS=str2double(April(c0,date+1));
   continue;
 end
end
TempCounterAW=CounterAW;
TempCounterPC=CounterPC;
TempCounterWS=CounterWS;
for c7=1:1:CounterName
 switch B(c7,6)
   case "Agape Way" %% First Preference = Agape Way
     if (CounterAW>0)
       CounterAW=CounterAW-1;
       AW(TempCounterAW-CounterAW,date)=B(c7,1);
     else
       switch B(c7,7)
         case "Peacock Court" %% Second Preference = Peacock Court
           if (CounterPC>0)
             CounterPC=CounterPC-1;
```

```
          CounterPC=CounterPC-1;
          PC(TempCounterPC-CounterPC,date)=B(c7,1);
        else
          CounterWS=CounterWS-1;
          WS(TempCounterWS-CounterWS,date)=B(c7,1);
        end
      case "Wilbur Square" %% Second Preference = Wilbur Square
        if (CounterWS>0)
          CounterWS=CounterWS-1;
          WS(TempCounterWS-CounterWS,date)=B(c7,1);
        else
          CounterPC=CounterPC-1;
          PC(TempCounterPC-CounterPC,date)=B(c7,1);
        end
      case "" %%Second Preference=NaN
        if (CounterWS>0)
          CounterWS=CounterWS-1;
          WS(TempCounterWS-CounterWS,date)=B(c7,1);
          continue;
        end
        if (CounterPC>0)
          CounterPC=CounterPC-1;
          PC(TempCounterPC-CounterPC,date)=B(c7,1);
          continue;
        end
    end
  end
case "Peacock Court" %% First Preference = Peacock Court
  if (CounterPC>0)
    CounterPC=CounterPC-1;
    PC(TempCounterPC-CounterPC,date)=B(c7,1);
  else
    switch B(c7,7)
      case "Agape Way" %% Second Preference = Agape Way
        if (CounterAW>0)
          CounterAW=CounterAW-1;
          AW(TempCounterAW-CounterAW,date)=B(c7,1);
        else
          CounterWS=CounterWS-1;
          WS(TempCounterWS-CounterWS,date)=B(c7,1);
        end
      case "Wilbur Square" %% Second Preference = Wilbur Square
        if (CounterWS>0)
          CounterWS=CounterWS-1;
```