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Original Study

Improving Access to Intermediate Care Through Flexibility: Simulation Study

Ismail Aydemir MSc [a,b,c,*], Casper G. van Loon MSc [b], René Bekker PhD [a], Bianca M. Buurman RN, PhD [c,d], Rob D. van der Mei PhD [a,b]

[a] Department of Mathematics, Vrije Universiteit Amsterdam, Amsterdam, the Netherlands
[b] Stochastics Group, Centrum Wiskunde & Informatica, Amsterdam, the Netherlands
[c] Department of Medicine for Older People, Amsterdam Public Health Research Institute, Amsterdam UMC, Vrije Universiteit Amsterdam, Amsterdam, the Netherlands
[d] Section of Geriatric Medicine, Department of Internal Medicine, Amsterdam Public Health Research Institute, Amsterdam UMC, University of Amsterdam, Amsterdam, the Netherlands

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ABSTRACT

Objective: Growing demand for intermediate care, combined with nurse shortages, is increasing the pressure on the accessibility of these services. This study uses simulation as an innovative approach to assess the effectiveness of policy interventions on waiting times and hospital admissions, aiming to identify strategies that better meet rising care demands and improve accessibility.
Design: A discrete-event simulation study modeling patient flows in intermediate care facilities.
Setting and Participants: The simulation model incorporates insights from health care professionals to represent patient flows, admissions, bed capacities, and operational constraints across both intermediate care and hospital settings.
Methods: The simulation model incorporates patient arrivals, admissions, and discharges within intermediate care. The study evaluates the impact of the following interventions on patient flow and accessibility: bed pooling between care types, flexible admission hours and transfer times, and the use of emergency beds.
Results: Partial bed pooling (10%) between high-complex and geriatric rehabilitation beds reduces waiting times by more than 1 day (a 25% to 42% reduction). Currently, average waiting times are approximately 2 days for low-complex care, and around 4 days for both high-complex care and geriatric rehabilitation. Expanding admission hours, particularly with 24/7 availability, decreases waiting times and hospital congestion. Eliminating emergency beds increases hospital admissions by 18%. By implementing multiple interventions, such as bed pooling and 24/7 admissions, accessibility shows the greatest improvement, with waiting times for high-complex patients reduced by more than 2 days (a 60% reduction) and decreased hospital admissions by 60%.
Conclusion and Implications: This study illustrates that access to intermediate care can be improved through bed pooling, flexible admission hours and transfer times, and the use of emergency beds, without the need to expand bed capacity. The results demonstrate that these interventions can optimize patient flow, reduce hospital admissions, and enhance overall system efficiency. Furthermore, the study demonstrates that simulation models are valuable tools for exploring policy and system changes within intermediate care settings.

Prolonged hospital stays have negative effects on patients, delay patient transitions, and lead to high costs.[1,2] Moreover, many older adults experience functional decline during hospital stays or require rehabilitation after discharge before they can return home. To address this, intermediate care facilities have been introduced. Intermediate care serves as a transitional step between hospital and home, providing patients with appropriate care for optimal recovery.[3] In addition to improving health outcomes, it is intended to

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* Address correspondence to Ismail Aydemir, MSc, Stochastics Group, Centrum Wiskunde & Informatica, Science Park 123, Amsterdam 1098XG, the Netherlands.
E-mail address: ismail@cwi.nl (I. Aydemir).

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reduce the number and duration of hospital admissions and lower costs.[4] For intermediate care to be effective, timely access to these facilities is essential. Currently, many patients experience prolonged hospital stays because of the limited access of intermediate care, which adversely affects their recovery and contributes to hospital congestion. A common approach to improve accessibility is by expanding capacity; however, limited access is not solely a consequence of capacity shortages, it may also result from the admission policy or from financial limitations.[5] Moreover, expanding capacity is not always feasible, for example because of nursing staff shortages. Hence, in this study we explore the effectiveness of policy interventions that are aimed at improving access to intermediate care, while efficiently using existing capacity. For this, we developed a discrete-event simulation (DES) model and applied it to a case study to evaluate the impact of different policy interventions on 2 key outcome measures: waiting time (in days) and hospital admissions. The following research question is addressed in this paper: Which interventions are most effective to improve intermediate care access without increasing bed capacity? To the best of our knowledge, the use of simulation models in intermediate care settings remains underexplored. Therefore, this study also aims to demonstrate the value and effectiveness of simulation tools in this context.

Methods

Intermediate Care

Intermediate care provides a range of short-term services designed to bridge the gap between hospital, home, and other care settings by ensuring continuity of care, facilitating recovery, and preventing functional decline.[3] Geriatric rehabilitation (GR) and short-term residential care (STRC) are both forms of intermediate care that are implemented in the Netherlands.

GR is a multidisciplinary approach designed to restore functional ability or enhance the functional capacity of older adults. The primary goal is to support frail older adults in gradually regaining independence so they can return home and live within the community. Treatment is delivered by a specialized multidisciplinary team, with typically up to 3 hours of therapy per week funded for a maximum of 6 months. GR is provided in nursing homes and rehabilitation centers. A nursing home physician leads the treatment, supported by a team of health care professionals.[6,7]

STRC provides bed-based support for general medical needs that do not require hospital admission for specialist care or rehabilitation but cannot be managed at home. The primary goal of STRC is to help older adults regain independence and return home. Treatment can be monodisciplinary or multidisciplinary. Funding typically covers up to 1.5 hours of therapy per week, whereas hospice care typically allows for up to 3 hours per week for a maximum of 3 years. STRC is offered in various settings, including nursing homes, care homes, rehabilitation centers, and care hotels. Care is provided by a general practitioner (GP) or nursing home physician, supported by a comprehensive team of health care professionals.[6]

Setting

The diagram in Figure 1 illustrates the patient flows into the intermediate care facility, the waiting lists, and represents the current practice. This model was developed based on in-depth discussions with regional managers and practitioners. The model distinguishes 3 types of care: low-complex (LC), high-complex (HC), and GR. Patient triage is based on the severity of the condition, which is the main factor in determining whether a patient is classified as LC or HC. Consequently, LC patients remain under the care of the GP, whereas HC patients are managed by a nursing home physician. Triage can occur through 1 of 3 pathways: (1) referral by a GP, (2) arrival via the emergency department (ED), or (3) transfer following a hospital admission. On entering the system, patients are either admitted directly if a bed is available or placed on a waiting list. Waiting list W1 consists of patients at home awaiting an available LC bed, whereas W2 and W3 include those in need of an HC bed. Although W2 and W3 represent a single waiting list in practice, they are separated here for illustration. W2 includes GP referrals waiting at home, whereas W3 consists of patients occupying hospital beds. The latter contributes to prolonged hospital stays, preventing beds from being used for new patients. As shown in the diagram, each care type—LC, HC, and GR—has its own dedicated beds. Furthermore, patients arriving from the ED can be placed in designated emergency beds at the intermediate care facility that are specifically allocated for ED referral. Besides patient flows, the simulation model also incorporates admission policies. Currently, admissions are restricted to weekdays between 8 AM and 5 PM. The average transfer time—the time required to make a bed available for admission, including preparation and coordination tasks—is 1.5 days, except for ED referrals, which have a shorter transfer time of 0.5 days. Because emergency beds in intermediate care are pre-designated, patients placed in these beds do not experience transfer delays. In addition, admissions from the ED to emergency beds are possible at any time, as these beds are accessible 24/7.

Twente

The Twente region, located in the eastern Netherlands, consists of 14 municipalities and has approximately 600,000 inhabitants. Within the region, there are 2 hospitals and 6 organizations that provide intermediate care. This case study focuses on 3 of these intermediate care organizations and 1 hospital.

Although the setting for intermediate care is largely consistent across the Netherlands, there are regional nuances; for example, whether LC care is offered. Twente provides a representative situation for intermediate care in the Netherlands, as it is a large region encompassing both urban and rural areas.

Interventions

Based on the model in Figure 1, we explore various what-if scenarios by implementing 3 different interventions to optimize patient flow and improve intermediate care accessibility: (1) bed pooling across different types of care, (2) flexible admissions and transfers, and (3) assessing the added value of emergency beds. These interventions were developed based on discussions with regional health care professionals.

Intervention 1: bed pooling

Bed pooling in intermediate care aims to pool beds among different care types. The primary advantage is the ability to accommodate a higher load per bed, thereby increasing the system's capacity. In addition, bed pooling introduces flexible bed utilization into the system, which has been shown to positively affect patient flow. Previous research showed that pooling can be effective in reducing waiting times.[8]

No pooling is the current admission policy in which each care type (LC, HC, and GR) has dedicated beds. There is no pooling of beds between different care types.

Partial pooling, as the name suggests, involves pooling a portion of the beds between HC and GR. These beds can be used when the dedicated beds for either GR or HC are fully occupied, providing some flexibility in the system.

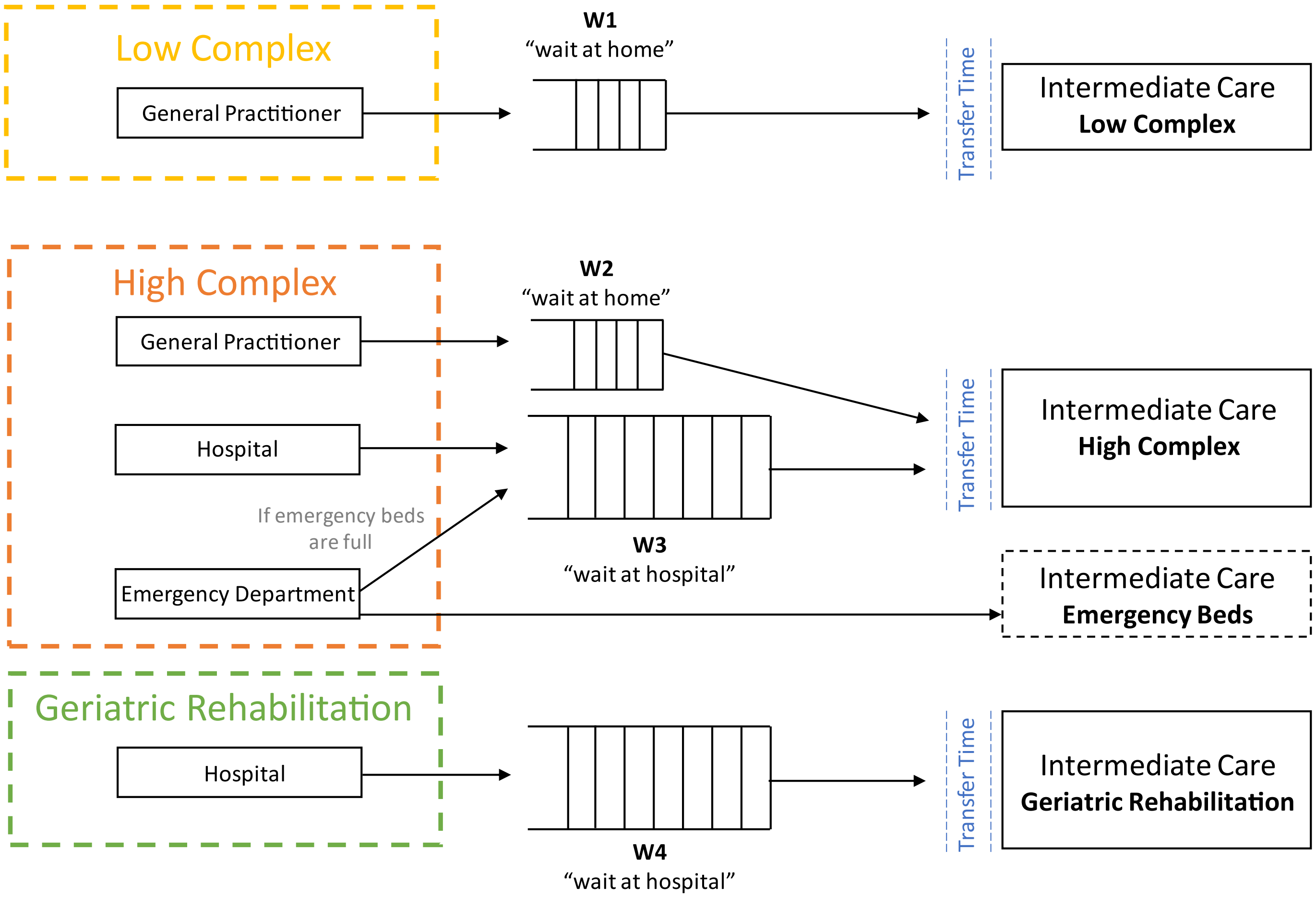

Fig. 1. The diagram illustrates the current practice, showing patient pathways into the intermediate care facility and associated waiting lists.

Full GR-HC combines the total number of HC and GR beds, excluding emergency beds, into a single shared resource pool of beds between these 2 care types. This arrangement maximizes the pooling potential for these care types but does not extend to LC care due to differences in care requirement and equipment.

Total bed pooling creates 1 large bed pool for all care types. Although HC and GR often cannot make use of LC beds in practice due to constraints such as room requirements, this hypothetical model is included to provide insights into potential effects of extensive bed pooling on the system. By exploring these different configurations, the study aims to understand how pooling beds can improve system efficiency, reduce waiting times, and optimize the use of available resources in intermediate care.

Intervention 2: admission and transfer

As previously mentioned, admissions to intermediate care are currently limited to weekdays between 8 AM and 5 PM, with no admissions during weekends. Previous research suggests that expanding admission hours can be effective.[4] In our study, we modeled the impact of extending admission hours—such as allowing evening or weekend admissions—on waiting times and hospital admissions. We also examined the effect of reducing the average transfer time, which is currently 1.5 days in practice. These interventions were analyzed to explore how they could improve access to intermediate care.

Intervention 3: emergency beds

The third intervention examines the impact of emergency beds within intermediate care on accommodating patient inflow from the ED. Facilities in Twente currently allocate emergency beds, which are designated for admissions from the ED and are accessible 24/7. Patients admitted to emergency beds from the ED will remain there until their treatment is completed, after which the beds will become available for new patients. Despite their use, their effectiveness in enhancing accessibility has not been fully evaluated. This study aims to determine whether, and to what extent, emergency beds within intermediate care contribute positively to patient flow and care accessibility.

Data

Data (Table 1) are obtained by conducting extensive discussions with regional professionals to gain insight regarding the arrivals and bed capacities. In addition, we used national data[9] on average length of stay to model service durations. Table 1 shows that, on average, 0.6 LC patients per day are referred by the GP. These patients have an average length of stay of 33 days, with an LC bed capacity of 42. For HC, an average of 1.55 patients per day are referred to intermediate care: 0.62 by the GP and the remainder from the hospital, including the ED. These patients also have an average length of stay of 33 days, with a total HC bed capacity of

Table 1
An Overview of 3 Key Parameters: Patient Arrivals, Length of Stay, and the Number of Beds per Care Type

Parameter	Mean Value		
	LC	HC	GR
Arrivals per day			
GP	0.6	0.62	0
Hospital	0	0.54	2.55
ED	0	0.39	0
Average length of stay, (days)	33	33	48
Number of beds			
Regular	42	57	136
Emergency	0	3	0

The information reflects 1 hospital and 3 care providers, with GR accounting for the largest patient flow and number of beds. HC care has a total of 60 beds, including 3 that are pre-designated as emergency beds. LC care referrals come only through GPs.

57. The largest group consists of GR patients, with an average of 2.55 referrals per day and an average stay of 48 days. GR has the largest bed capacity, with 136 beds.

Simulation

DES is a computational modeling technique enabling analysis and optimization. It represents the system as a sequence of time-based events, in which each event signifies a state change within the system.[10,11] In health care, patient arrivals and discharges are examples of such events. The admission policy and flow diagram (Figure 1) are essential in modeling system behavior, making a thorough understanding of these elements important. In addition, the data (Table 1) serve as input for the simulation model. Patient arrivals are modeled as Poisson processes, whereas service durations follow an exponential distribution, both are commonly used assumptions in modeling health care systems.[12-14] Using DES, we evaluate the effectiveness of interventions across the 3 care types based on 2 key outcome measures: waiting time (in days) and hospital admissions (as a percentage). Waiting time reflects the average duration between application and placement in intermediate care, hospital admissions indicate the percentage of patient admissions from the ED that could not be directly placed in an HC intermediate care bed. The latter also can be considered an avoidable hospital admission, as these patients are admitted only to bridge the waiting period until placement, rather than for medical reasons. The simulation model was developed using MATLAB (https://www.mathworks.com/products/matlab.html). We did not use any pre-built simulation tools; the model was built from scratch. As a result, the same model could be implemented using other (open-source) software. The simulation consists of 100 batches, each containing 30,000 runs, with a warm-up period of 9000 runs per batch. To ensure reusability for other regions and countries, we have described the study setting and simulation model in line with the STRESS-DES guidelines.[15]

Results

Current Practice

Current waiting times and hospital admissions in the Twente region are shown in Table 2 (current practice). Patients wait up to 2 days for LC care and around 4 days for HC or GR. Furthermore, due to unavailable beds or limited admission hours, 65% of ED patients are admitted to the hospital to bridge the waiting period until placement.

Table 2
Waiting Times and Hospital Admissions, With 95% CI, for the Current Practice in the Twente Region, as Well as the Results on the Effectiveness of Different Interventions Compared With Current Practice

Intervention	Average Waiting Time in Days			Hospital Admissions
	LC	HC	GR	Percentage (%)
Current practice	2.10 (2.09–2.11)	3.85 (3.62–4.06)	4.15 (3.91–4.37)	65 (64–65)
Bed pooling				
Partial 10%	2.10 (2.09–2.11)	2.24 (2.19–2.30)	3.11 (2.98–3.24)	60 (59–60)
Partial 50%	2.10 (2.09–2.11)	2.38 (2.29–2.46)	2.68 (2.56–2.78)	60 (59–60)
Full GR-HC	2.10 (2.09–2.11)	2.41 (2.34–2.48)	2.48 (2.41–2.55)	60 (59–60)
Total	2.04 (2.03–2.05)	2.00 (2.00–2.00)	2.04 (2.04–2.05)	58 (57–58)
Admissions and transfers				
0.5 Transfer Day	1.10 (1.10–1.11)	2.19 (2.08–2.29)	2.20 (2.04–2.36)	63 (62–63)
+2 hours weekdays	2.05 (2.04–2.05)	3.85 (3.59–4.14)	4.01 (3.68–4.33)	62 (61–62)
Saturday open	1.83 (1.82–1.83)	3.31 (3.14–3.47)	3.62 (3.35–3.89)	62 (61–62)
Weekend open	1.69 (1.69–1.70)	2.98 (2.83–3.12)	3.25 (2.98–3.50)	58 (57–58)
24/7 open	1.50 (1.49–1.50)	2.68 (2.53–2.83)	2.85 (2.67–3.02)	23 (22–24)
Emergency beds				
0 Emergency beds	2.10 (2.09–2.11)	3.87 (3.66–4.08)	4.15 (3.91–4.37)	83 (82–83)
3 Emergency beds	2.10 (2.09–2.11)	3.85 (3.62–4.06)	4.15 (3.91–4.37)	65 (64–65)
6 Emergency beds	2.10 (2.09–2.11)	3.89 (3.66–4.13)	4.15 (3.91–4.37)	48 (47–48)
Combination				
Partial 10%				
0.5 Transfer day	1.10 (1.10–1.11)	1.27 (1.24–1.31)	1.68 (1.60–1.75)	59 (58–59)
1 Transfer day	1.60 (1.60–1.61)	1.75 (1.71–1.78)	2.44 (2.33–2.55)	59 (58–59)
24/7 Open	1.50 (1.49–1.50)	1.52 (1.48–1.55)	2.19 (2.11–2.27)	5 (5–6)
Partial 50%				
0.5 Transfer day	1.10 (1.10–1.11)	1.23 (1.21–1.26)	1.33 (1.30–1.36)	59 (58–59)
1 Transfer day	1.60 (1.60–1.61)	1.78 (1.74–1.81)	1.98 (1.92–2.02)	59 (58–59)
24/7 Open	1.50 (1.49–1.50)	1.59 (1.55–1.63)	1.80 (1.75–1.85)	5 (5–6)
Full GR-HC				
0.5 Transfer day	1.10 (1.10–1.11)	1.31 (1.26–1.35)	1.34 (1.29–1.39)	59 (58–59)
1 Transfer day	1.60 (1.60–1.61)	1.84 (1.78–1.88)	1.88 (1.83–1.93)	59 (58–59)
24/7 Open	1.50 (1.49–1.50)	1.65 (1.60–1.68)	1.69 (1.64–1.73)	5 (5–6)

Hospital admissions refers to patients admitted from the emergency department as a result of arrivals outside admission hours or a lack of available beds.

Bed Pooling

Table 2 presents results for the intervention of bed pooling, allowing for a comparison with the baseline scenario ("current practice"), as illustrated in the flow diagram (Figure 1). Partially pooling as little as 10% of HC and GR beds already results in a reduction of waiting times by more than 1 day (a 25% to 42% reduction) for both care types. Increasing the pooling percentage to 50% slightly reduces the waiting time for GR beds while causing a minor increase for HC beds compared with 10% pooling. In the full GR-HC scenario (100% partial pooling), waiting times for GR beds decrease further, whereas HC beds see a slight increase. The largest reduction in waiting times is observed when all beds across the 3 care types are pooled. In addition, pooling beds between HC and GR reduces hospital admissions from the ED by 5%.

Admission and Transfer

Table 2 highlights the effects of extending admission hours. Adding 2 extra admission hours on weekdays slightly reduces waiting times for LC and GR beds compared with the current practice, but the effect is not clinically meaningful. Enabling admissions on 1 weekend day already leads to a significant reduction in waiting times, whereas opening both weekend days results in an even greater impact. The largest impact occurs when intermediate care facilities allow 24/7 admissions. It reduces waiting times by more than 1 day (a 30% to 34% reduction) for HC and GR beds and decreases hospital admissions from the ED by more than 40%. In addition, reducing transfer time from 1.5 days to 0.5 days leads to a 1-day reduction for LC beds and nearly a 2-day reduction for HC and GR beds, in terms of waiting times. From a clinical standpoint, 24/7 admissions may not be feasible. However, they serve to illustrate the potential benefits of expanding admission hours.

Emergency Beds

The effectiveness of emergency beds in intermediate care is shown in Table 2. Although adjusting the number of emergency beds does not impact waiting times, it significantly reduces hospital admission—by 18% with 3 emergency beds (current practice) and by 35% with 6 emergency beds.

Combination

We also examined the combined effects of bed pooling, flexible admission hours, and reduced transfer times. Some of these results are presented in Table 2. In addition, Figure 2 illustrates waiting times for bed pooling between HC and GR under different transfer times. Although the overall trend remains stable, the combination of bed pooling and reduced transfer times leads to a greater reduction in waiting times than bed pooling alone. Specifically, with a transfer time of 0.5 days and 10% partial pooling, waiting times decrease by 2.5 days (a 59% to 67% reduction) for both HC and GR.

Similarly, Figure 3 shows the impact of combining 24/7 admissions with bed pooling, compared with the current admission hours. Although 10% partial pooling with 24/7 admissions reduces waiting times for HC and GR beds by 2 days (a 47% to 60% reduction), the most significant effect is on hospital admissions from the ED, reducing to 5%. This highlights the potential of combining interventions, which results in a greater decrease in waiting times than implementing them individually.

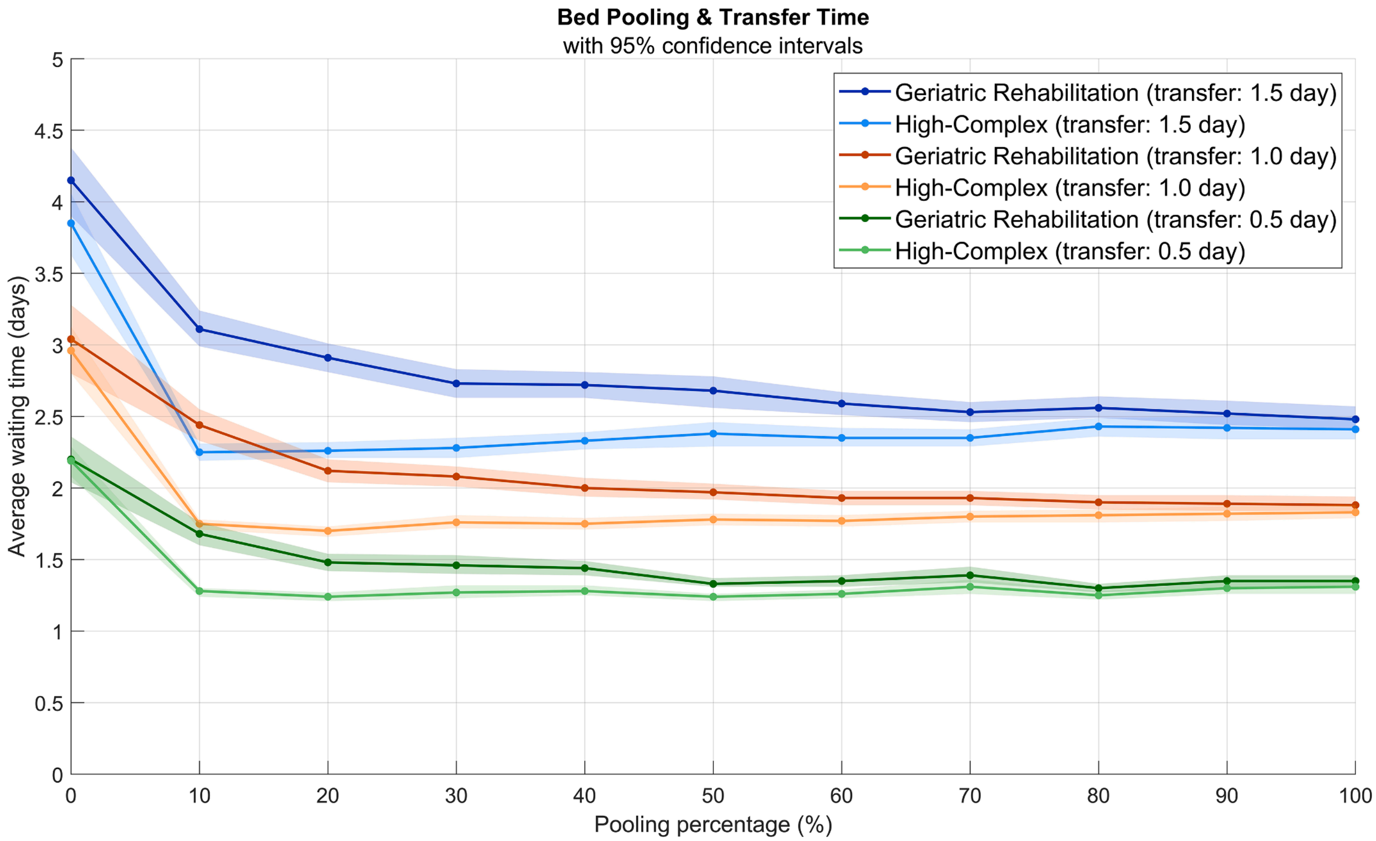

Fig. 2. Simulation results of bed pooling under varying transfer times.

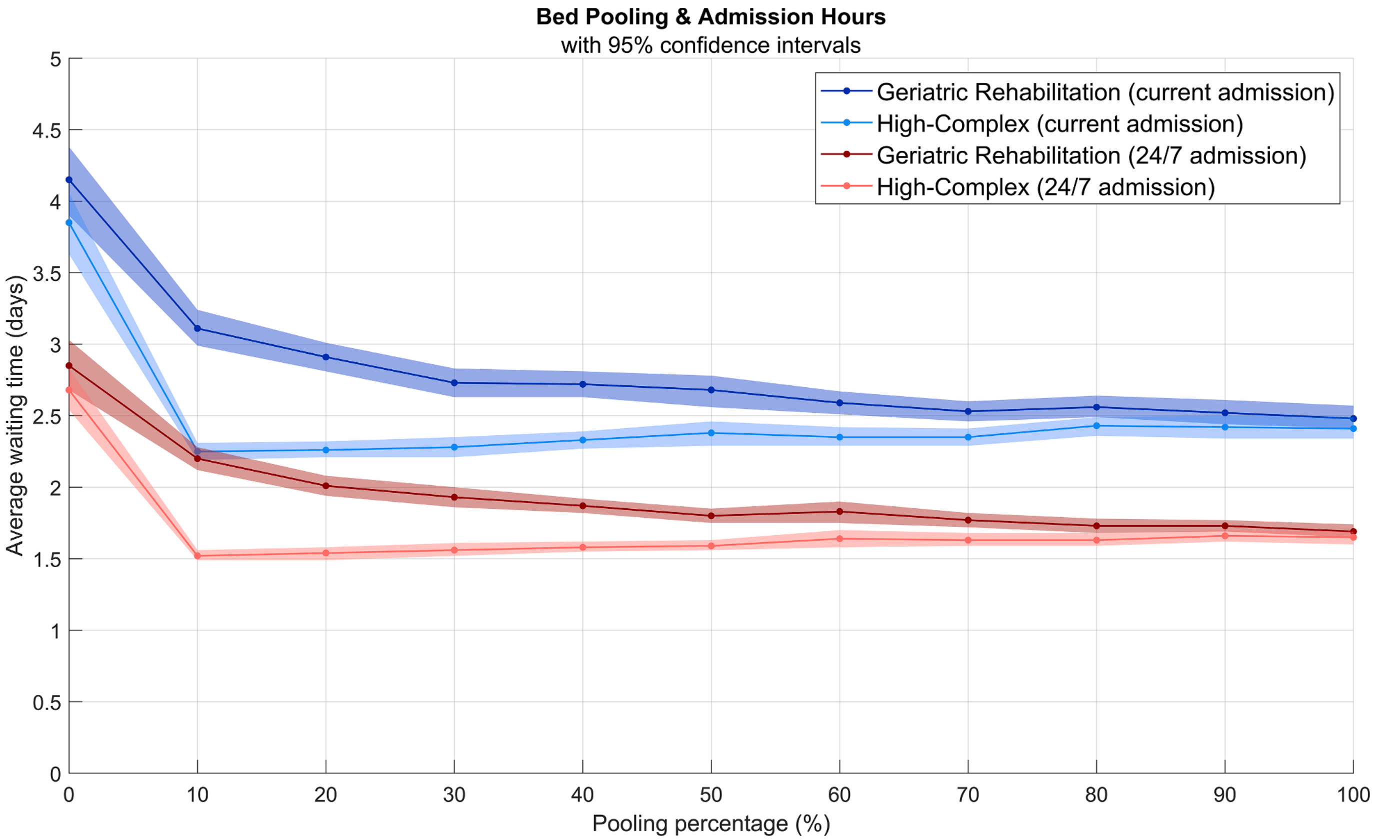

Fig. 3. Simulation results of bed pooling under varying admission hours.

Discussion and Limitations

This research explored policy interventions for improving access to intermediate care without expanding bed capacity. By using a DES model, we evaluated the impact of 3 interventions: bed pooling, flexible admissions and transfers, and the use of emergency beds. The results shows that these interventions can be effective to significantly reduce waiting times and hospital admissions, thereby improving patient flow, optimizing capacity utilization, and reducing hospital congestion.

Bed pooling can be highly effective even when partially applied, pooling just 10% of beds between HC and GR reduces waiting times by more than 1 day. This demonstrates that even a small amount of flexibility in bed utilization can lead to significant benefits. The maximum reduction in waiting times in terms of bed pooling, with a decrease of 2 days (a 48% to 50% reduction) for HC and GR beds, is achieved through total bed pooling across all care types. The results of bed pooling align with previous studies demonstrating that flexible bed allocation can optimize capacity utilization and reduce bottlenecks.[8]

Regarding flexible admission hours, effectiveness depends strongly on the extent of the expansion. Extending admissions by only 2 hours has minimal impact, whereas expanding to 24/7 admission results in substantial improvements, particularly reducing hospital admissions by more than 40%. Thus, for flexible admission hours to serve as an effective intervention, the expansion should ideally fall within this range. The same applies to reducing transfer times, which also can be an effective intervention. However, practical constraints may limit reductions, making zero transfer time unlikely to achieve.

These results suggest administrative constraints, rather than physical bed shortages, limit intermediate care access, consistent with prior studies indicating restrictive admission policies hinder hospital throughput and patient transitions.[5]

Although emergency beds within intermediate care do not directly impact waiting times, our findings indicate that removing them leads to a 18% increase in hospital admissions. This highlights their role in preventing hospital admission. Thus, maintaining emergency beds in intermediate care is important for improving patient flow and reducing hospital congestion.

Briefly, the largest reduction in waiting times occurs with 0.5 transfer time. Bed pooling proves to be more effective than extending admission hours. In terms of hospital admissions, allowing for 24/7 intermediate care admissions results in 42% decrease in hospital admissions from the ED. However, combining 24/7 admissions with 10% partial bed pooling yields the maximum benefit, cutting HC bed waiting times by 2 days and reducing hospital admissions by 60%. Thus, combining interventions is more effective than implementing them individually.

Although research on modeling intermediate care systems and evaluating related policies remains limited, the underlying approach closely resembles that used for health care systems in other countries. When comparing our findings with studies in the broader international health care sector, we see consistent results. Admission policies are shown to play a vital role in hospital settings—not only in reducing congestion and enhancing patient flow, but also in terms of care quality and costs.[16] In line with our approach, one study on hospital bed utilization found that flexible bed allocation can help relieve bed pressure, although it may come with a small increase in daily nursing costs.[17] Another study showed that even partial flexibility in bed allocation can be effective in reducing delays in hospital admissions.[18] Furthermore, the findings of our study underscore the impact of the complex hospital discharge process (represented by transfer time in this study), which contributes to prolonged hospital stays. This issue is not unique to our setting; other countries face similar challenges, often resulting in bed-blocking and deterioration in patients' conditions.[19,20]

The main strength of this study is the use of a DES model, allowing for a detailed analysis of patient flow and system performance. This method enables the evaluation of policy interventions in a controlled environment, providing insights into their effectiveness on intermediate care.

The limitations of this study primarily stem from data availability and accuracy. However, this does not undermine the essential value of the interventions, it only implies that the actual benefits for the Twente region may differ from our findings. Moreover, given minor differences in intermediate care settings across regions, the simulation model will require slight adjustments to serve as a generalizable tool. In addition, the effectiveness of emergency beds is highly dependent on the guidelines surrounding their use. If these beds are more accessible than assumed in our study, their impact may be greater than indicated. On the other hand, if access is more restricted, their effectiveness could be lower, making the outcome highly dependent on the underlying assumptions.

Conclusions and Implications

This study shows that intermediate care access can be improved through flexible policy interventions without the need of capacity expansion. Using a DES for the Twente region, we evaluated bed pooling, flexible admissions and transfers, and emergency beds, all of which significantly reduced waiting times and hospital admissions.

Bed pooling proved highly effective, with just 10% partial pooling cutting waiting times by more than 1 day. Expanding admission hours can reduce waiting times by up to 1 day. Emergency beds also play a crucial role, as their removal led to an 18% rise in hospital admissions.

The most substantial improvements came from the combination of interventions. Notably, combining 24/7 admissions with 10% partial bed pooling reduced waiting times by 2 days and reduced admissions from the ED to 5%. These findings highlight the potential of flexible bed utilization and admission policies to enhance patient flow.

By adopting these strategies, health care administrators and policymakers can work toward reducing hospital congestion, minimizing unnecessary delays, and improving access to intermediate care.

Disclosure

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