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## Patients' Perspectives and Feasibility of Home Monitoring in Acute Care: The AcuteCare@Home Flash Mob Study

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### Abstract

**Objective:** To determine patients' perspectives on home monitoring at emergency department (ED) presentation and shortly after admission and compare these with their physicians' perspectives.

**Methods:** Forty Dutch hospitals participated in this prospective flash mob study. Adult patients with acute medical conditions, treated by internal medicine specialties, presenting at the ED or admitted at the admission ward within the previous 24 h were included. The primary outcome was the proportion of patients who were able and willing to undergo home monitoring. Secondary outcomes included identifying barriers to home monitoring, patient's prerequisites, and assessing the agreement between the perspectives of patients and treating physicians.

**Results:** On February 2, 2023, in total 665 patients [median age 69 (interquartile range: 55–78) years; 95.5% community dwelling; 29.3% Modified Early Warning Score  $\geq 3$ ; 29.5% clinical frailty score  $\geq 5$ ] were included. In total, 19.6% of ED patients were admitted and 26% of ward patients preferred home monitoring as continuation of care. Guaranteed readmission (87.8%), ability to contact the hospital 24/7 (77.3%), and a family caregiver at home (55.7%) were the most often reported prerequisites. Barriers for home monitoring were feeling too severely ill (78.8%) and inability to receive the required treatment at home (64.4%). The agreement between patients and physicians was fair (Cohens kappa coefficient 0.26).

**Conclusions:** A substantial proportion of acutely ill patients stated that they were willing and able to be monitored at home.

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#For the Onderzoeks Consortium Acute Geneeskunde (ORCA) Research Consortium.

*Guaranteed readmission, availability of a treatment team (24/7), and a home support system are needed for successful implementation of home monitoring in acute care.*

**Keywords:** *home monitoring, acute care, patients, physicians, perspectives, telemedicine*

## Introduction

**H**ome monitoring refers to the regular measurement of a patient's condition in the home environment, making use of remote monitoring instruments and communication systems. Based on this monitoring, a health care professional can provide timely interventions and support to patients from a distance. Home monitoring is used in patients with chronic conditions, such as congestive heart failure and chronic obstructive pulmonary disease (COPD).<sup>1-5</sup> The care provided was found safe and effective,<sup>6-10</sup> reduced the number of hospital admissions and emergency department (ED) presentations,<sup>2</sup> improved quality of life,<sup>11</sup> and decreased costs.<sup>5,9-12</sup> The acute setting is, however, different from that in chronic conditions, where there is time for instruction and assessment of the cognitive capability of patients, and where the course of the disease is predictable, without an immediate threat to clinical deterioration.

Home monitoring was successfully introduced in the acute setting during the COVID-19 pandemic. It reduced hospital stay without compromising the quality of care.<sup>13-17</sup> In other acute conditions, such as community-acquired pneumonia and cellulitis, limited evidence is available about safety and cost-effectiveness.<sup>5</sup>

Retrieving the patients' perspectives is an important step in developing home monitoring in acute care.<sup>18</sup> Their perspectives may vary significantly in health, chronic illness, and during acute clinical deterioration for which an ED visit is required. During an ED visit, patients are generally physically and mentally not in a steady state, which may influence their behavior, wishes, and capabilities.<sup>19</sup> In addition, the perspective may change shortly after acute hospital admission and may differ between patient and health care provider.<sup>20,21</sup>

To address these knowledge gaps on the potential role of home monitoring in acute care and to guide its future implementation, we conducted a flash mob study in The Netherlands.<sup>22</sup> We aimed to investigate patients' perspectives at ED presentation to identify (1) both barriers to and prerequisites for home monitoring and (2) which medical patients felt able and were willing to be monitored at home. In addition, we compared the perspective of patients at ED presentation with

that of patients shortly after hospital admission and the perspective of patients with that of their physicians.

## Methods

### STUDY DESIGN AND SETTING

In total, 40 hospitals, including 8 University Medical Centers, teaching and nonteaching hospitals in The Netherlands, participated in a nationwide, multicenter questionnaire-based 14-hour flash mob study (Supplementary Table S1). The design is based on the idea of a "Flash Mob," a spontaneously assembled group of people that performs an extraordinary act in public for a brief period of time before dispersing.<sup>22</sup> With a flash mob design, clinically relevant data can be prospectively collected from a large number of patients in a short time-period. We chose this design to enable participation from various types of hospitals and to retrieve nation-wide and generalizable data quickly. The AcuteCare@Home flash mob study took place on February 2, 2023 between 8AM and 10PM.

The study was designed by the Dutch Research Consortium Acute Internal Medicine (ORCA) and prepared by a small steering committee consisting of three investigators from Leiden University Medical Center and Maastricht University Medical Center. The steering group invited physicians from every hospital in The Netherlands to participate. For local study coordination and data collection at each participating hospital, a local investigator ("an ambassador") was chosen. None of the participating hospitals has currently implemented home monitoring in routine acute care.

### STUDY PARTICIPANTS

All adult patients ( $\geq 18$  years) with an acute medical (non-trauma) condition (i.e., geriatrics, gastroenterology, hematology, nephrology, clinical immunology, oncology, pulmonology, infectious diseases, and rheumatology) at the ED (irrespective of having an indication for hospital admission), or who had been acutely admitted to the ward within the previous 24 h, were eligible to participate.

In The Netherlands, general practitioners (GPs) typically refer patients to the ED,<sup>23,24</sup> where medical care is delivered by specialists (e.g., internists and emergency physicians) and their residents.<sup>25</sup>

### DATA COLLECTION

Local investigators interviewed patients or their proxy using the AcuteCare@Home questionnaire (Supplemental File S2). The patients were asked about their living situation, their experience with home monitoring, and about the availability of and competency with several communication and medical instruments required for home monitoring. We further asked

them about the prerequisites for home monitoring, about their preferences for continued care, and questioned the patients why they believed they could not be monitored at home, if applicable.

From the patients' medical ED charts, we retrieved: sociodemographic characteristics, vital signs (needed for the calculation of the Modified Early Warning Score [MEWS]), current cognitive state, clinical frailty scale (CFS) before the acute illness (Rockwood<sup>26</sup>), and discharge destination (Supplemental File S3). The reason for ED presentation was categorized into 15 groups.

Using a second questionnaire (Supplemental File S4), the treating physician was asked about the feasibility of home monitoring and their estimation of the capabilities of the patients.

### OUTCOME MEASURES

The primary endpoint was the proportion of patients who indicated they were able and willing to be monitored at home. This proportion was calculated for different predefined subgroups: age (age <65 vs. ≥65), patients with and without cognitive impairment, and for CFS (<5/≥5).

Secondary endpoints were (1) the prerequisites according to the patient, (2) barriers to home monitoring for patients, (3) the agreement between the patient's perspective and the treating physician regarding the feasibility of home monitoring, and (4) the proportion of patients who said they could be sent home with home monitoring the morning after admission.

We compared ED patients who needed to be admitted (ED-admitted) with those who had already been admitted (ward-patients) regarding the proportion choosing home monitoring as a feasible option either for continued care or when looking back (in retrospect).

### SAMPLE SIZE

Intrinsic to the flash mob approach, no fixed sample size could be set a priori.<sup>20,22</sup>

### STATISTICAL ANALYSIS

Baseline characteristics and questionnaire responses were analyzed using descriptive statistics. Percentages were expressed as valid percentages. Chi-square or Fisher's Exact tests were used to compare proportions and to examine differences in discharge destination between the included patients and those not included, aiming to analyze inclusion bias.

The agreement between the responses of patients and physicians was measured using the Cohen's Kappa coefficient. Patients who stated that they did not need home monitoring were excluded from this agreement analysis. Associations between patient characteristics and being candidate for home monitoring according to patient and physician were analyzed by calculating odds ratios.

All calculations were made using SPSS Statistics 25.0 for Windows. Figures were made using GraphPad Prism version 9.3.1 for Windows, San Diego, CA.

### REPORTING AND ETHICS

The study was approved by the medical ethics committee of Maastricht UMC (METC-2022-3339) and the scientific boards of all participating hospitals. All participants provided informed consent. The study was described according to the STROBE checklist (Supplementary File S1) on reporting study outcomes.<sup>27</sup>

## Results

### PARTICIPATING HOSPITALS AND ELIGIBLE PATIENTS

On the study day, all data were simultaneously collected in 40 participating hospitals from across the country. The patient flow is depicted in *Fig. 1*. The questionnaires were well completed (Supplementary Tables S3–S6).

### BASELINE CHARACTERISTICS

In total, 665 patients were included in the study: 441 (66.3%) at the ED and 224 (33.7%) at the medical wards (*Fig. 1, Table 1, and Supplementary Table S2*). The median age was 69 years (interquartile range: 55–78). Almost all (95.5%) patients were community dwelling, of whom 34.1% lived alone. In total, 31.7% had been brought in by ambulance and 29.3% had a MEWS ≥ 3. In addition, 10.8% had pre-existent or acute cognitive disorders and 29.5% of patients had a CFS ≥ 5. The three most prevalent reasons for ED visit were infections (22.9%), abdominal pain (9.9%), and exacerbation of COPD/asthma (8.7%).

Following the ED visit, 264 of the 441 patients (59.9%) were admitted to the hospital (*Fig. 1*); 5 of them were admitted to the medium care unit/intensive care unit (MCU/ICU).

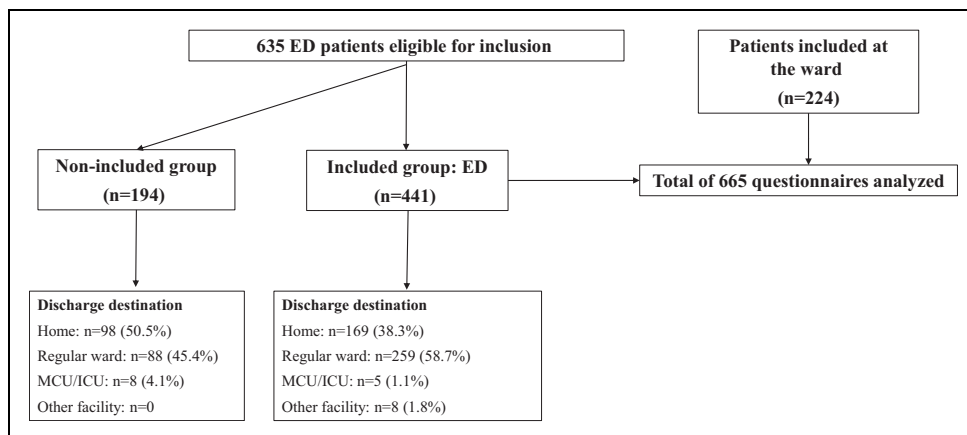
### EXPERIENCE WITH AND PRACTICAL ASPECTS OF HOME MONITORING

Of all patients, 34.4% reported to have heard of home monitoring before and 14.0% had experience with home monitoring (Supplementary Table S3).

The majority of patients owned a mobile phone (91.6%) and most were able to use it independently (86.9%, Supplementary Table S4). Furthermore, 89.5% were connected to the internet, which could be used independently by 78.7%. Most patients owned some kind of medical instrument to measure vital signs, most commonly a thermometer (84.8%). Only 41.9% of patients reported to be able to use a smartwatch and a minority (15.2%) owned one.

From the patients' perspective, the three most often reported prerequisites for home monitoring were: guaranteed readmission





**Fig. 1.** Flowchart of patients. Abbreviations: ED; emergency department; ICU, intensive care unit; MCU, medium care unit.

(87.8%), the ability to contact the hospital 24/7 (77.3%), and someone to watch over the patient (family caregiver, 55.7%) (Fig. 2, Supplementary Table S5). The main required medical instruments according to patients were an oxygen saturation meter (59.8%) and a blood pressure monitor (48.5%). The preferred way of contacting the health care professional was by phone (62.1%) or video calling (22%), followed by app (10.5%) and email (5.5%).

#### PATIENT PERSPECTIVE ON HOME MONITORING AS CONTINUED CARE

In total, 19.6% of ED patients who were admitted and 26.0% of the ward patients preferred home monitoring as continued care (Table 2). On the admission ward, 14.7% of the patients indicated that, looking back at the moment of ED visit the preceding day, discharge with home monitoring would have been possible. This proportion was significantly lower than in the ED patients who were asked in the ED and who wanted to go home with monitoring [22.4% (51/228; 32 patients who wanted to go home without monitoring were excluded),  $p = 0.04$ ].

The three most common barriers for home monitoring indicated by patients were: feeling too ill (78.8%), inability to receive the required treatment at home (64.4%), or feeling unsafe at home (43.9%, Fig. 3). Of the patients who lived alone, 56/216 (25.9%) indicated that home monitoring was feasible. Among these, 12/56 (21.4%) had a CSF  $\geq 5$  and 6/56 (10.7%) reported cognitive impairments.

#### PHYSICIAN PERSPECTIVE ON HOME MONITORING IN ACUTE CARE

Physicians indicated that hospital admission could have been prevented in 23.2% of their patients, whereas in 11.3% this might be possible ("doubt"). According to physicians, 42% of patients

were judged to have capabilities for home monitoring both physically and cognitively, and to have a safe home situation. They judged that 59.6% of patients were physically and 75.9% were cognitively capable of using home monitoring. The home situation was estimated sufficiently safe in 66.8% of patients.

#### AGREEMENT BETWEEN PATIENTS AND PHYSICIANS

In 64.2%, both patients and physicians agreed regarding the feasibility of going home with home monitoring (21.5% capable, 42.7% not capable; see Supplementary Table S6). In

11.3%, patients considered home monitoring possible, whereas physicians did not, and conversely, in 24.5%, the physicians considered home monitoring possible, but the patients did not. The Cohens kappa coefficient was 0.26, indicating fair agreement.<sup>28</sup>

#### ASSOCIATION BETWEEN PATIENT CHARACTERISTICS AND FEASIBILITY FOR HOME MONITORING

The opinion on capability regarding home monitoring was compared between patients and physicians and was examined by different patient characteristics. The patterns in judgement about being a candidate for home monitoring were comparable between patients and physicians (Supplementary Table S7). Overall, patients who considered themselves/were considered no candidates for home monitoring were: older than 65 years, transported by ambulance, having cognitive impairment, a CFS  $\geq 5$ , or a MEWS  $\geq 3$ . In contrast, most patients with venous thromboembolism were considered more often candidates for home monitoring by both patients and physicians. The only dissimilarity in judgement pattern between patients and physicians was abdominal pain as reason for presentation at the ED.

#### Discussion

In this national multicenter flash mob study, we investigated patient's perspectives on home monitoring for acute medical conditions. We found that one in five medical ED patients and one in four recently admitted patients stated that home monitoring was a suitable alternative for hospital admission. Those who were less severely ill (MEWS  $< 3$ ), young ( $< 65$  years), had a CFS  $< 5$ , had no cognitive impairment, and did not arrive in an ambulance considered

**Table 1. Baseline Characteristics of Patients**

	ALL PATIENTS (n = 665)
Age, median (IQR)	69 (55–78)
Age ≥65 years, N (%)	407 (61.2%)
Male, N (%)	347 (52.2%)
Pre-existent living situation, N (%) <sup>a</sup>	
Community dwelling	634 (95.5%)
Alone	216 (34.1%)
Family caregiver available	81 (37.5%)
With roommate	418 (65.9%)
Can function as family caregiver	375 (89.7%)
Nursing home	30 (4.5%)
Transport by ambulance, N (%)	211 (31.7%)
MEWS, median (IQR)	1 (1–3)
MEWS, N (%) <sup>a</sup>	
MEWS 0–2	452 (70.7%)
MEWS 3–4	133 (20.8%)
MEWS ≥5	54 (8.5%)
Cognitive disorders, N (%)	72 (10.8%)
Pre-existent	37 (5.6%)
Acute	20 (3.0%)
Combination of pre-existent and acute	15 (2.3%)
CFS, median (IQR)	3 (2–5)
CFS ≥ 5, N (%)	195 (29.5%)
Specialty N (%) <sup>a,b</sup>	
Internal medicine	383 (57.9%)
Pulmonary medicine	178 (26.9%)
Gastroenterology	112 (16.9%)
Rheumatology	1 (0.2%)
Reason for ED presentation, N (%)	
Infection/Sepsis	152 (22.9%)
Abdominal pain	66 (9.9%)
Exacerbation COPD/Asthma	58 (8.7%)
Venous thromboembolism	41 (6.2%)
General malaise	37 (5.6%)
Acute bleeding	34 (5.1%)
Anemia (no acute bleeding)	35 (5.3%)

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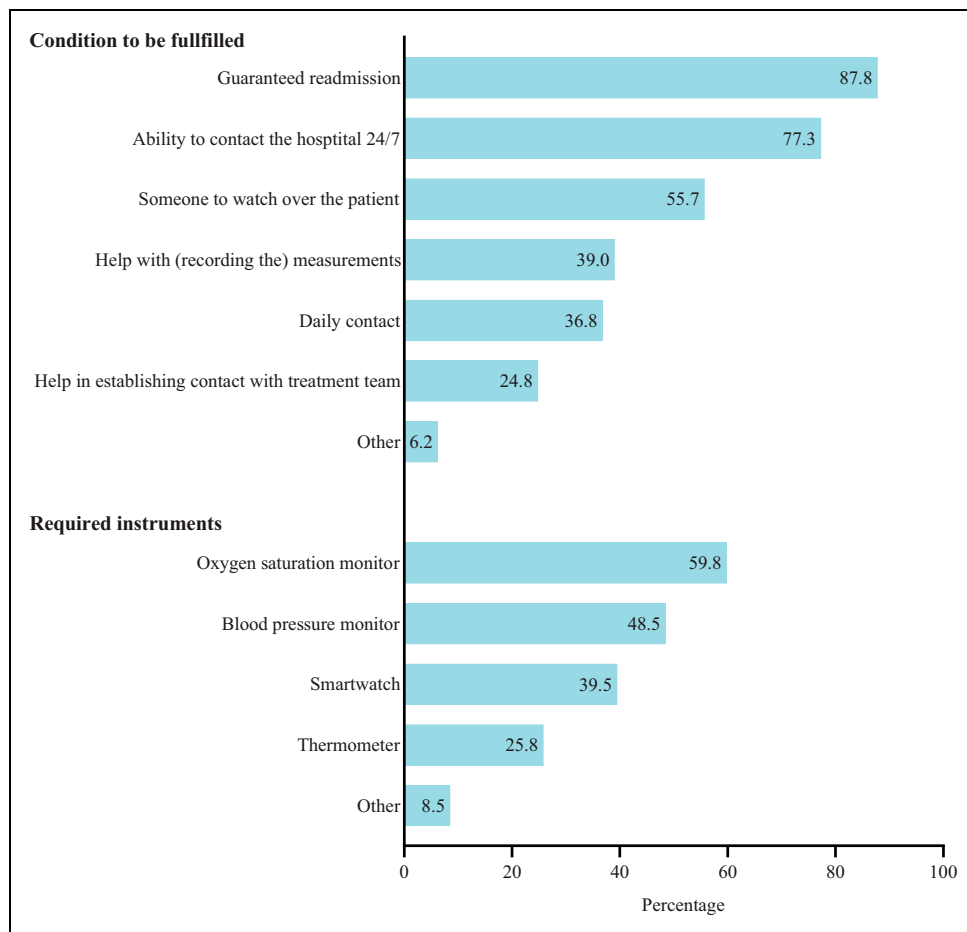
**Table 1. Baseline Characteristics of Patients *continued***

	ALL PATIENTS (n = 665)
<i>Complication of imm/onco/hemat treatment</i>	43 (6.5%)
<i>Metabolic dysregulation</i>	32 (4.8%)
<i>Acute kidney injury</i>	22 (3.3%)
<i>Heart failure</i>	11 (1.7%)
<i>Intoxication</i>	7 (1.1%)
<i>Diabetes mellitus</i>	5 (0.8%)
<i>Other</i>	122 (18.3%)

<sup>a</sup>Because of missing data, numbers do not add up to 665; valid percentages were calculated.  
<sup>b</sup>As a maximum of two specialties could be chosen, percentages do not add up to 100%.  
 CFS, rockwood clinical frailty scale; ED, emergency department; imm/onco/hemat, immunological, oncological or hematological treatment; IQR, interquartile range; MEWS, modified early warning score.

themselves/were considered candidates for home monitoring more often. Among others, guaranteed readmission if home monitoring should fail and access to the treatment team 24/7 were prerequisites for home monitoring. According to patients, it was necessary to supply instruments that measure vital signs. Half of the patients indicated they needed someone to watch over them. Having support is an important prerequisite, as studies conducted before indicated that those without support at home may be more likely to decline,<sup>29,30</sup> whereas in addition, this support was important in helping patients in using remote monitoring service.<sup>31</sup> In our study, 34% of patients lived alone, but two-thirds had a family caregiver who could watch over them and provide help.

The physician judged 42% of the patients to be capable of home monitoring. However, in only 23% of the patients, the physician judged home monitoring to be a suitable alternative for continued care. The potential of avoiding a quarter of acute admissions or reducing hospital stay after one night of admission could be an underestimation as we did not design an extensive care package (e.g., high-tech monitoring or communication systems) but asked about the use of monitoring and communication instruments that the patients already had. In addition, most physicians were not familiar with the concept of home monitoring. Furthermore, we did not discuss the role the hospital treatment team, the patients' GP nor the district nurses could play in home monitoring. The potential for home monitoring in acute care may be further increased



**Fig. 2.** Patient opinion on prerequisites for home monitoring.

by using user-friendly technology, a well-organized home monitoring program and involving both professionals in the hospital and the patient's (informal) care system.

We found fair agreement between patients and physicians regarding feasibility of home monitoring. Agreement is important for successful implementation of home monitoring. Physicians are not always able to accurately assess the feasibility of home monitoring because not only practical skills but also socio-economic status and the patient's willingness to accept home monitoring are important as well.<sup>32</sup> The timing of our questions, which were infrequently asked at the same time for the patient and the physician, may explain another part of the disagreement. The answers to the questions may change during the course of the ED stay.

Fewer patients indicated that home monitoring was possible as continued care on the day after admission than when looking back at the moment of their ED visit one day earlier or when comparing with ED patients who were admitted. Explanations for this difference could be that the quality or intensity of provided care was high or that patients experienced

clinical deterioration within the preceding day. The two most common reasons indicated by the patient why going home with home monitoring was not an option were feeling too severely ill and the inability of receiving the treatment at home.

Although the home situation was estimated as sufficiently safe in two-thirds of the patients by the physician, more than half of the patients reported having feelings of unsafety at home. This is in contrast with another report where only 20% of acutely ill patients declined to participate in a home hospital model because they felt safer in the hospital.<sup>30</sup> One explanation for this difference may be that the model in that study involved more comprehensive care than in our study. In addition, fewer participants lived alone than in our study. Furthermore, our study included many vulnerable individuals (29.5% had a CSF  $\geq 5$ ) who might experience a high sense of insecurity in their domestic environment. What may help in decreasing feelings of unsafety is fulfilling the prerequisites indicated by the patients (medical

instruments available, treatment team accessible 24/7, guaranteed admission). Studies found that the care provided was secure<sup>6,7</sup> and that patients responded very positively regarding the care provided.<sup>31</sup> It may be worthwhile as well to include GPs in the design, implementation, and execution of home monitoring.

A strength of this study is its flash mob design. Because of this design, large academic, teaching hospitals, and smaller hospitals could collaborate. This resulted in a diverse study cohort of acute patients, enhancing the external validity. In addition, we included patients with all kinds of medical diagnoses and a considerable proportion of patients were old and frail. The analysis concerning inclusion bias showed that in the not-included group relatively more patients were discharged home and were admitted to the MCU/ICU. These groups of patients are less relevant for our study as they either do not require home monitoring or are too ill for home monitoring.

**Table 2. Patient Opinion on Home Monitoring as Continued Care**

	ED-ADMITTED PATIENT (n = 260) <sup>a</sup>	WARD PATIENT (n = 223) <sup>b</sup>	WARD PATIENT IN RETROSPECT (n = 218)
Admission	177 (68.1%)	133 (59.6%)	186 (85.3%)
Home with monitoring	51 (19.6%)	58 (26.0%)	32 (14.7%)
Home without monitoring	32 (12.3%)	32 (14.3%)	—

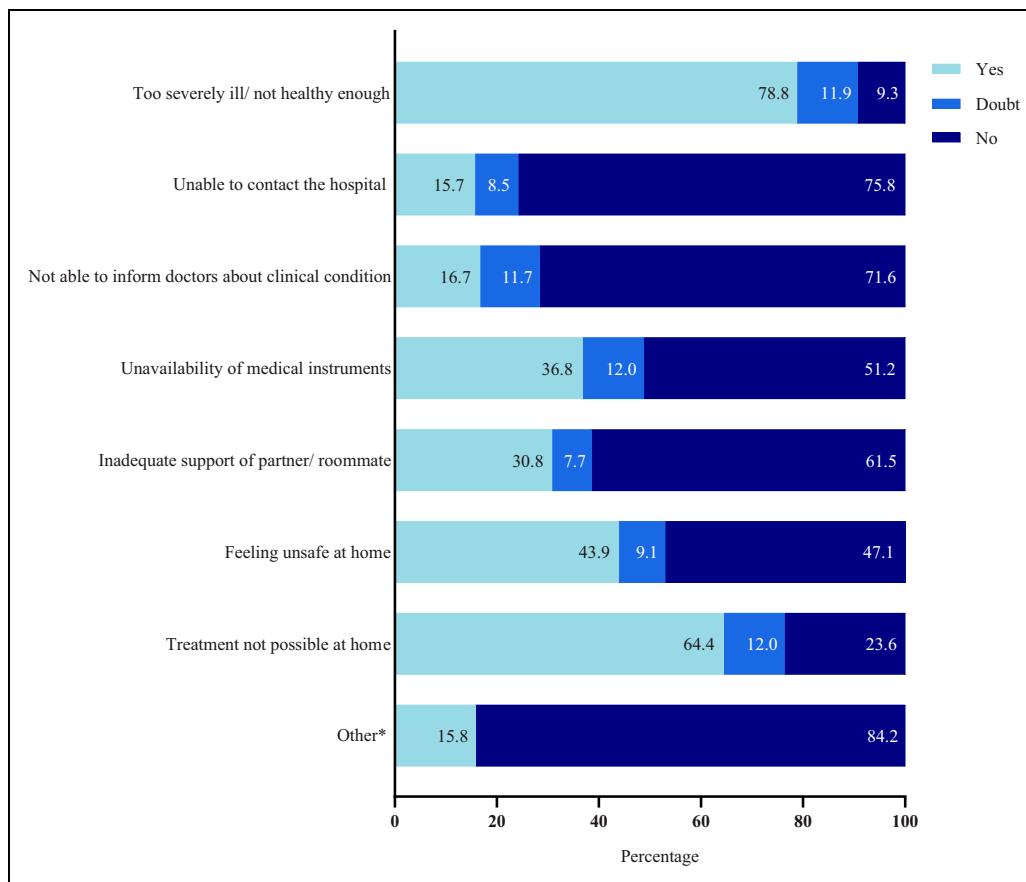
<sup>a</sup>Answers of four patients were missing.

<sup>b</sup>Answer of one patient was missing.

ED, emergency department.

The study also has some limitations. Because of the flash mob design, numerous investigators collected the data, allowing some variation in the interpretation of the questionnaires. This may have introduced bias into the results. However, the completion rate was almost 100%. In addition, the data were collected during only one day and the patients presenting at the ED might differ during the week or night,

limiting generalizability. We, however, also included patients who had already been admitted for one day and a part of these had visited the ED during the night. Potential bias owing to random effects emerging from the short inclusion period can be balanced by our large sample size. In addition, patients and physicians were not familiar with the concept of home monitoring, thereby influencing the responses. Last, we



**Fig. 3.** Barriers for home monitoring. \* “Other” barriers were unavailability of diagnostics at home (n = 10, 2.9%), the medical problem was not being suitable for home monitoring (n = 8, 2.3%; e.g., severe pain, observation after anaphylactic reaction), and an unknown diagnosis (n = 6, 1.7%).



had to create a new questionnaire because research on this topic in acute care is lacking. The questionnaire was therefore not validated and provided only quantitative data. In the future, questionnaires should be created preferably building on insights we yielded and more qualitative aspects should be included.

## Conclusions

Our study demonstrated that, from patients' perspective, home monitoring is seen as a feasible alternative to hospital admission in acute care in one fifth of the patients. In addition, a dedicated home support system closely connected with the treatment team is essential.

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Marijke van Gerwen, MD, Medisch Centrum Leeuwarden, Leeuwarden, The Netherlands, and Harriët M.R. van Goor, University Medical Center Utrecht, Utrecht, The Netherlands, additionally contributed to this work.

## Authors' Contributions

The AcuteCare@Home Study Group contributed to the study design. All coauthors contributed to the analysis and interpretation of the data. M.P. and J.W. did the statistical analysis. M.P., J.W., D.D., P.S., and G.G. drafted the article. All authors contributed to revision of the article and gave final approval of the version to be published. M.P. and J.W. contributed equally to this work. J.W., M.P., D.D., and P.S. had access to the data in the study, and all authors take responsibility for the integrity and accuracy of the analysis. The corresponding author attests that all listed authors meet authorship criteria and that no others meetings the criteria have been omitted. G.G. is the guarantor.

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**Supplementary Material**

- Supplementary File S1
- Supplementary File S2
- Supplementary File S3
- Supplementary File S4
- Supplementary Table S1
- Supplementary Table S2
- Supplementary Table S3
- Supplementary Table S4
- Supplementary Table S5
- Supplementary Table S6
- Supplementary Table S7

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