Changes in vital signs post discharge as a potential target for intervention to avoid readmission

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Abstract

Readmissions are treated as adverse events in many healthcare systems. Causes can be physiological deterioration or breakdown of social support systems.

We investigated data from a European multi-centre study of readmissions for changes in vital signs between index admission and readmission. Data sets were graded according to the National Early Warning Score (NEWS).

Of 487 patients in whom NEWS could be calculated on discharge and again on re-admission, 39.6% had worse vital signs with a NEWS score difference ≥ 2 points while only 7.6% had improved by ≥ 2 points. Changes in individual vital signs of 20% or more were most common in respiratory rate and heart rate.

Monitoring of respiratory rate and pulse rate post-discharge might predict some deteriorations.

Keywords

Readmission; Vital Signs; Deterioration; National Early Warning Score

Key points

- Readmission after deterioration of vital parameters is common
- These vital parameters can be self-monitored at home
- Self-monitoring of vital parameters might prevent readmission due to timely intervention

Backgroud

In European healthcare systems discharges from hospital are followed by an unplanned readmission within 30 days in 10-30% of patients.[1] Unplanned readmissions are treated as adverse events in many healthcare systems. Studies performed by our group have shown that suboptimal communication is an avoidable cause for some readmissions but many readmissions are probably not due to errors of commission or omission by care teams.[2-4]

In the CURIOS@ study we demonstrated that patients opinion such as not being ready to be discharged was associated with likely preventability and predictability of a readmission in a significant proportion of readmissions.[3] More than two-third of the readmissions in this cohort were judged as having disease-related root causes (67.9%; 4,686 of 6,895 of the root causes). A study by Nguyen et. al[5] found that instability of vital signs at the time of discharge was incrementally associated with increased readmission within 30 days.

We therefore hypothesized that in a subgroup of patients who were readmitted within 30 days worsening of disease severity could be demonstrated by changes in vital signs. Readmissions with deterioration in vital signs after discharge might potentially be preventable by monitoring of vital signs at home.

Methods

The data collection for the CURIOS@ study has been described elsewhere[3].

In brief, we prospectively collected data available on readmission to hospital as well as key information from the index admission including vital signs required to calculate the National Early Warning Score (NEWS) on discharge and readmission,[6] the Clinical Frailty Scale (CFS) at admission[7] and Charlson Co-morbidity Index (CCI) at admission.[8] Patients, their next of kin and clinical teams were asked whether the readmission was in their personal opinion preventable or predictable. 15 hospitals in four European countries recruited 1,398 medical patients with unscheduled readmissions within 30 days from discharge.

Ethics

Ethics Committees of all participating sites individually approved the study, after primary approval was obtained by the coordinating centre [VU University medical center (VUmc) Amsterdam].

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Severity of illness

We measured severity of illness during the index admission by collecting the last available set of vital signs in the 48 hours prior to discharge. We measured severity of illness at readmission with the first set of vital signs available in the first 24 hours after entering hospital. Severity was scored using the NEWS.[6] NEWS requires measurement of respiratory rate, oxygen saturations, fraction of inspired oxygen, systolic blood pressure, heart rate, level of consciousness and temperature. Each parameter is scored for the degree of abnormality by allocating zero points (normal) to three points (very abnormal).

Definition of physiological deterioration

We divided the patient cohort into three groups based on the difference between NEWS on discharge during the index admission and NEWS at the time of readmission. An increase in the value of the NEWS by two points or more was classified as deterioration, a decline in the value of NEWS by two points or more was classified as improvement. Changes between minus one and plus one NEWS points were classified as equivocal.

For systolic blood pressure and oxygen saturation a decrease in values was considered as deterioration. For respiratory rate, temperature and pulse rate an increase in values was considered as deterioration.

Analysis

The changes in vital parameters of patients in each group were calculated from discharge to readmission. The proportion of patients who had at least 20% worsening in their vital parameter in each group was also calculated. Groups were compared with regards to patient characteristics and frailty.

Results

Patient characteristics

CURIOS@ collected data from 1,398 patients. In 565 patients a NEWS score could be calculated from the last set of vital signs for the index admission. In 907 patients a NEWS score could be calculated from the first set of vital signs at readmission to hospital. In 487 patients both sets of vital signs were available to calculate relative changes. The mean age of this cohort was 66.5 years (SD ± 17), 226 patients (46%) were female, the median level of frailty as classified according to the Clinical Frailty Scale was 5 (mildly frail) [SD ± 2].

Patients in which both NEWS could not be calculated had significantly more often a do not resuscitate policy ($p<0.001$) than those in which both NEWS could be calculated.

When compared to the group in which a NEWS difference could not be calculated patients in which both NEWS could be calculated had a higher CFS frailty score ($p<0.001$), a higher respiratory rate ($p<0.001$) and higher temperature at time of discharge during the index admission ($p=0.046$) and a higher temperature at readmission ($p=0.001$). There was no difference in CCI in groups in which the difference in NEWS could be calculated when compared to those in which the difference in NEWS could not be calculated. Those who had both NEWS available had a mean CCI of 2.77, while those without both NEWS had a CCI of 2.86 ($p=0.09$).

Other patient characteristics or vital parameters also did not differ significantly between the group in which both NEWS could be calculated and the group in which this could not be done. Table 1 provides a complete overview of patient characteristics and vital parameters.

Differences of groups based on changes in NEWS between discharge and readmission

NEWS increased by ≥2 points between discharge and readmission (i.e. deteriorated) in 193 patients, decreased by ≥2 points (i.e. improved) in 37 patients, and 257 had an equivocal change (i.e. changed by no more than 1 point) (Figure 1).

Those who deteriorated did not differ in frailty from patients in the equivocal group ($p=0.063$) or those that improved ($p=0.198$). A difference in resuscitation policy was not found between the deteriorating patients and the equivocal ($p=0.135$) or improved group ($p=0.528$).

Deterioration in subgroups depending of NEWS at discharge during index admission

In patients with a NEWS of 0-2 at time of discharge during index admission deterioration occurred in 154 of 373 patients (41.3%), in those with a NEWS of 3-6 deterioration occurred in 37 of 105 patients (37.1 %). In the 9 patients with a NEWS of ≥ 7 at discharge no patient was admitted with worse physiology.

Individual vital signs in deteriorating patients

In the cohort of deteriorating patients (n=193) different vital signs contributed to worsening values of NEWS in different patients. Mean changes in parameters between discharge at index admission and readmission were small for systolic blood pressure (-0.9%), oxygen saturations (-1.7%) and temperature (+1.4%), but were large in respiratory rate (+28.3%) and pulse (+22.9%). See table 2 for further details.

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Table 1a. Patient characteristics per group

	All patients (±SD) (n=1398)	Patients without NEWS measured at both discharge and readmission (±SD) (n=911)	Patients with NEWS measured at both discharge and readmission (±SD) (n=487)
Mean age (years)	67.6 (± 15.5)	68.1 (± 14.8)	66.5 (± 16.6)
Gender (male/female) (%)	53/47	52/48	54/46
CCI at index admission	2.8 (± 2.3)	2.9 (± 2.3)	2.8 (± 2.3)
CFS at index admission	4.4 (± 1.6)	4.2 (± 1.6)	4.7 (± 1.7)
Marital status (partner/no partner) (%)	59/41	62/38	55/45
Respiratory rate at discharge (breaths per minute)	16.1 (± 3.2)	15.2 (± 3.7)	16.4 (± 3.1)
Respiratory rate at readmission (breaths per minute)	18.6 (± 5.3)	18.8 (± 5.4)	18.8 (± 5.1)
Saturations at discharge (% saturation)	96.0 (± 2.5)	95.6 (± 2.6)	96.1 (± 2.5)
Saturations at readmission (% saturation)	96.0 (± 3.5)	96.2 (± 3.3)	95.9 (± 3.8)
Systolic blood pressure at discharge (mmHg)	129.9 (± 22.0)	130.8 (± 22.1)	128.5 (± 21.8)
Systolic blood pressure at readmission (mmHg)	132.3 (± 25.9)	132.7 (± 26.4)	131.6 (±25.0)
Pulse discharge (beats per minute)	79.6 (± 15.8)	79.1 (± 16.3)	80.3 (± 14.9)
Pulse readmission (beats per minute)	88.1 (± 21.1)	87.4 (± 21.5)	89.3 (±20.2)
Temperature discharge (degrees celsius)	36.8 (± 0.6)	36.8 (± 0.6)	36.7 (± 0.6)
Temperature readmission (degrees celsius)	37.1 (± 1.0)	37.2 (± 1.0)	37.0 (± 1.0)

Table 1b. Patient characteristics per subgroup of NEWS difference at readmission

	NEWS equivocal at readmission (±SD) (n=257)	NEWS increased at readmission (±SD) (n=193)	NEWS decreased at readmission (±SD) (n=37)
Mean age (years)	66.6 (± 16.2)	66.3 (± 17.1)	66.9 (± 17.0)
Gender (male/female) (%)	51/49	57/43	57/43
CCI at index admission	2.8 (± 2.3)	2.8 (± 2.3)	3.0 (± 2.1)
CFS at index admission	4.6 (± 1.6)	4.9 (± 1.7)	5.2 (± 1.6)
Marital status (partner/no partner) (%)	56/44	54/46	49/51
Respiratory rate at discharge (breaths per minute)	16.1 (± 2.9)	16.4 (± 2.8)	18.5 (± 4.2)
Respiratory rate at readmission (breaths per minute)	16.8 (± 3.2)	20.9 (± 6.3)	17.2 (± 3.0)
Saturations at discharge (% saturation)	96.3 (± 2.3)	96.2 (± 2.4)	94.1 (± 3.1)
Saturations at readmission (% saturation)	96.7 (± 3.1)	94.6 (± 4.6)	96.5 (± 2.2)
Systolic blood pressure at discharge (mmHg)	129.3 (± 21.2)	129.0 (± 21.4)	120.1 (± 26.0)
Systolic blood pressure at readmission (mmHg)	135.2 (± 22.9)	126.1 (± 27.2)	135.1 (± 22.2)
Pulse discharge (beats per minute)	79.9 (± 15.0)	80.4 (± 13.5)	83.2 (± 20.0)
Pulse readmission (beats per minute)	84.2 (± 16.9)	97.5 (± 22.0)	82.1 (± 16.5)
Temperature discharge (degrees celsius)	36.7 (± 0.6)	36.7 (± 0.6)	36.9 (± 1.0)
Temperature readmission (degrees celsius)	36.8 (± 0.7)	37.2 (± 1.3)	36.7 (± 0.5)

*Normal values of physiological parameters according to the National Early Warning Score (NEWS):
- Respiratory rate in breaths per minute: 12 – 20
- Saturation in %: > 96%
- Systolic blood pressure in mmHg: 111-219
- Pulse rate in beats per minute: 51-90
- Temperature in degrees celsius: 36.1 – 38.0

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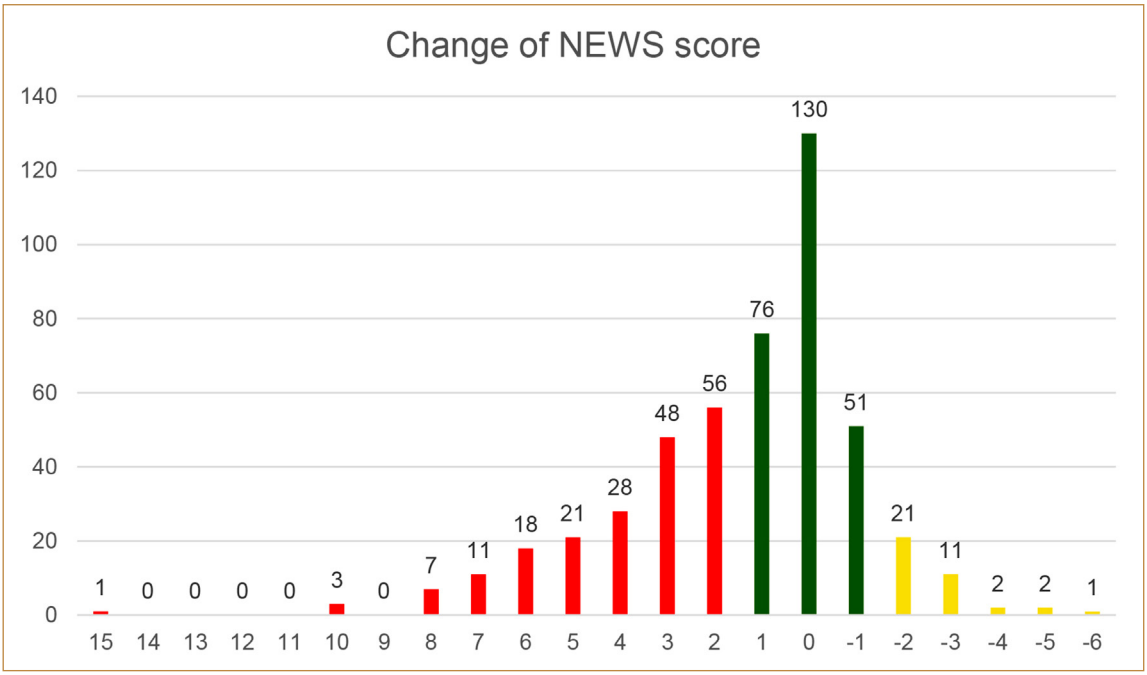

Figure 1. Changes in NEWS score. Positive values (red) indicate worsening, negative values (yellow) improvement between discharge during the index admission and readmission. Green columns were considered as equivocal.

In the patients who had increased NEWS at readmission, worsening of at least one vital parameters by at least 20% between discharge and readmission occurred in 83 patients (43.0%). In 62 patients (32.1%) at least two vital parameters worsened by ≥ 20%.

In six patients (3.1%) worsening by more than 20% occurred in three vital parameters.

When compared to discharge, vital signs worsened by at least 20% in 99 patients for respiratory rate, 89 patients for pulse and 36 for systolic blood pressure. One patient had a 20% deterioration in saturation while none had such a deterioration of temperature.

Discussion

What we have shown

To our knowledge this is the first study that has prospectively examined the proportion of all patients who are readmitted to the hospital with objective signs of post-discharge deterioration in vital signs when compared to their index opinion. Using our previously defined cut-off criteria,

Table 2. Vital parameters of patients who deteriorated after discharge

Vital sign	Mean ± SD	Mean change of vital parameter in absolute numbers	Mean change of vital parameter in %	Proportion of patients with ≥ + 20% deterioration* (%)
Blood pressure discharge (mmHg)	129.0 (± 21.4)	-2.9	-0.9%	36/193 (18.6%)
Blood pressure readmission (mmHg)	126.1 (± 27.2)			
Respiratory rate discharge (breath per minute)	16.4 (± 2.8)	+4.4	+28.3%	99/193 (51.2%)
Respiratory rate readmission (breath per minute)	20.9 (± 6.3)			
Saturation discharge (%)	96.2 (± 2.4)	-1.6	-1.7%	1/193 (0.5%)
Saturation readmission (%)	94.6 (± 4.6)			
Pulse discharge (beats per minute)	80.4 (± 13.5)	+ 17.1	+22.9%	89/193 (46.1%)
Pulse readmission (beats per minute)	97.5 (± 22.0)			
Temperature discharge (Celsius)	36.7 (± 0.6)	+0.5	+1.4%	0/0 (0%)
Temperature readmission (Celsius)	37.2 (± 1.3)			

*Deterioration defined as a decrease of blood pressure or saturations or an increase of either respiratory rate, pulse or temperature.

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39.6% of patients in whom NEWS scores could be calculated from vital signs on discharge from hospital and at readmission deteriorated following their index admission. Those who were admitted with deteriorating vital signs did not differ in frailty from those who were not. The most common deteriorating vital sign was respiratory rate and heart rate.

What others have shown

Several studies have examined the monitoring of vital parameters in patients.

A study on vital parameters instability at the time of discharge found vital parameters to be associated with 30-day readmission.[5] This finding emphasizes the value of these parameters in regards to readmission.

Home monitoring following discharge from hospital has been used in patients with Chronic Obstructive Pulmonary Disease[9,10] and chronicle heart failure.[11,12] Monitored parameters in these studies included oxygen saturations, weight, heart rate and systolic blood pressure.

NEWS consists of a combination of vital parameters and has been validated primarily for inpatients. However, there is evidence that NEWS is able to capture an increase in the risk of death in patients seen in the prehospital setting by district nurses or by paramedics in ambulances.[13,14]

Strength and weakness

Physiological data has not been part of most studies examining patients readmitted to hospital. The inclusion of these data in our study distinct it from other studies.

CURIOS@ collected data from 1,398 patients but we were only able to measure deterioration in 565 patients. This reveals NEWS measurement and documentation has not yet been embedded in every hospital structure. CURIOS@ represents a comparatively small study of patients admitted to a limited number of heterogeneous hospitals. At the same time prognostic value of NEWS has been shown to be valid well beyond the units where it was developed.[15]

Clinical implications

Vital signs are universally measured in patients admitted and discharged from hospital. Additionally, home monitoring equipment for systolic blood pressure, temperature and oxygen saturations are available to prices affordable by the public and more and more wearable devices are able to capture vital signs such as heart rate, respiratory rate and movement.[16] It is therefore perceivable to measure some or all of the parameters required to identify possible deterioration in the patients' home. Previous work has shown that patients, even those with disabilities, in general are satisfied with the self-monitoring of vital signs at home.[17,18]

By focusing measurements in high risk groups this might add value to existing care pathways involved early follow-up by General Practitioners and District Nurses used in current clinical practice to safety-netting of patients post-discharge.

Implications for research

Prospective studies using home monitoring with key parameters are required for patients outside the current groups with a firm evidence base such as COPD or heart failure. The fact that patients' readiness for discharge was a significant co-factor leading to re-admission in the CURIOS@ study would suggest that this pathway of more engaged collaboration with patients post-discharge might be at least worth exploring.

Conclusion

Readmission after physiological deterioration is common and might potentially be preventable by monitoring of vital signs at home.

Conflict of interest statement

The authors have no conflicts of interest to disclose.

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