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Title page

The accuracy and feasibility of respiratory rate measurements in acutely ill adult patients by general practitioners: a mixed-methods study

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Key words: respiratory rate; general practice; primary care; after-hours care; sepsis

ABSTRACT

Background

Tachypnoea in acutely ill patients can be an early sign of a life-threatening condition such as sepsis. Routine measurement of the respiratory rate by GPs might improve the recognition of sepsis.

Aim

To assess the accuracy and feasibility of respiratory rate measurements by GPs.

Design and Setting

Observational cross-sectional mixed-methods study in the setting of out-of-hours home visits at three GP cooperatives in the Netherlands.

Methods

GPs were observed during the assessment of acutely ill patients, and semi-structured interviews were performed. The GP-assessed respiratory rate was compared to a reference measurement. GPs were asked to estimate the rate to be ≥22 breaths per minute or not, in case the respiratory rate was not counted.

Results

Observations of 130 acutely ill patients were included, and 14 GPs were interviewed. In 33 patients (25%), the GP counted the respiratory rate. A mean difference of 0.27 breaths per minute (95% CI -5.7 to 6.3) with the reference measurement was found. At a cut-off point of ≥22 breaths per minute, a sensitivity of 86% (95% CI 57-98%) was found when the GP counted the rate, and a sensitivity of 43% (95% CI 22-66%) when GPs estimated respiratory rates. GPs reported both medical as practical reasons for not routinely measuring the respiratory rate.

Conclusion

GPs are aware of the importance of assessing the respiratory rate of acutely ill adult patients, and counted measurements are accurate. However, in most patients the respiratory rate was not counted, and the rate was often underestimated when estimated.

How this fits in

Tachypnoea can be the first clinical sign of critical illness such as sepsis. The feasibility and accuracy of the respiratory rate measurement by GPs during assessment of acutely ill adult patients is unknown. This study shows GPs are able to accurately measure the respiratory rate during home visits of acutely ill patients, but in only one of four patient contacts the rate was counted during at least 15 seconds. In case the respiratory rate was not counted, tachypnoea was missed in more than half of the patients. Both the feasibility and validity of clinical scores using the respiratory rate as one of the parameters may therefore be limited in primary care.

INTRODUCTION

The respiratory rate is an important sign to identify seriously ill patients early in the course of the disease.[1-3] According to the Airway, Breathing, Circulation, Disability, Exposure (ABCDE) approach, the respiratory rate should be measured as part of the assessment of 'Breathing".[4] The ABCDE approach is widely used in acute care settings and increasingly taught in general practitioners' (GPs) training programs.[5,6] The respiratory rate is deemed important for the early recognition of sepsis. In the early stage of sepsis, cytokines and endotoxins increase the respiratory drive leading to hyperventilation beyond the metabolic needs. In later stages, metabolic acidosis and lung injury induced by sepsis further increase the respiratory drive.[7] Both the Systemic Inflammatory Response Syndrome (SIRS), and the quick Sequential Organ Failure Assessment (qSOFA) score use the respiratory rate as one of the variables in the score. [8,9] The cut-off points in the SIRS and qSOFA are respectively >20 breaths per minute and ≥22 breaths per minute. Also, the respiratory rate is included in warning scores such as the National Early Warning Score (NEWS) and Modified Early Warning Score (MEWS), which are used to recognise critically ill patients, including sepsis patients.[10] Besides for suspected sepsis, the respiratory rate can be used to assess the likelihood and/or severity of acute conditions such as pulmonary embolism, heart failure, pneumonia and COPD exacerbations.

Currently, it is not known if GPs can measure the respiratory rate reliably and in which clinical scenarios GPs assess it. This study aims to examine the accuracy of the respiratory rate measurement by GPs and evaluate barriers and facilitators for measuring it in acutely ill adult patients.

METHODS

The study consisted of observations of respiratory rate measurements during the assessment of acutely ill adult patients. Semi-structured interviews with GPs were held during the shift of the GP in which the home visits were conducted. Informed consent was obtained from the participating GPs. The need for informed consent from the patients was waived as all patients received care as usual. Patients were asked if they agreed with the presence of a member of the research team during the GP assessment.

Setting

We conducted the study between May 2018 and June 2019 at three out-of-hours (OOH) GP cooperatives located in Ede, Den Bosch and Uden, serving about 700,000 inhabitants in a mixed urban and rural area. In Dutch OOH GP cooperatives, each patient contact is preceded by telephonic triage by a trained triage nurse supervised by a GP. If possible, telephonic advice is given, or patients are asked to come to the OOH GP cooperative for a GP consultation. If this is not feasible, a GP visits the patient at home. If an acute life-threatening condition, such as myocardial infarction, is suspected, an ambulance is directly deployed to transport the patient to a hospital.[11] At all participating GP cooperatives, contacts with acutely ill adult patients who received a home visit were included in the study to observe respiratory rate measurements. These contacts mainly concerned frail elderly patients with urgent medical complaints for whom assessment could not be postponed to the next working day. Therefore, all patients were considered acutely ill unless a clear other reason for the home visit was present (e.g. determination of death, palliative care or psychiatric emergencies). At the GP cooperative in Ede only, semi-structured interviews with the GP were performed.

Patient observations

During home visits of acutely ill adult patients, a member of the research team (medical intern) was present during GP assessment of the patient. GPs were asked to measure the respiratory rate when medically indicated, without specific instruction in which patients and how to perform the measurement. During the home visit, the research team member counted the respiratory rate as a reference value by observing the thorax excursions for 60 seconds while the patient was not talking or moving. The reference measurement was usually performed during the physical examination by the GP, but the exact timing and result were concealed for the GP, as the observing researcher was positioned behind the GP and did not provide any information about the measurement to the GP.

Directly after the patient consultation, we asked the GP if he or she measured the respiratory rate and, if so, what the value and method of measurement were. If the GP counted the respiratory rate for at least 15 seconds, the value was recorded as a counted value. In case the GP assessed the respiratory rate without counting the exact rate for at least 15 seconds, we only recorded whether the estimated rate was ≥22 breaths per minute (cut-off value of the qSOFA). At the GP cooperative where GPs were also interviewed for the study, we asked GPs after each contact with an acutely ill patient to estimate the value (≥22 breaths per minute or not), in case the rate was not counted.

Qualitative research among GPs

The research team member performed a semi-structured interview with the GP at the beginning of or during the shift. This interview lasted about 10 minutes in total. The interviews were continued until data saturation was observed. The main topics of the interview were 1) the frequency and method of the respiratory rate measurement during patient assessments, 2) the clinical scenarios in which they usually measure the respiratory rate, and 3) the perceived relevance of the measurement.

Data analyses

The quantitative data were analysed using SPSS version 25. Descriptive analyses were used for the background characteristics of the included patients and GPs. Mean values with standard deviation (SD) were used for normally distributed continuous variables and median with interquartile range (IQR) for skewed distributions. Pearson's correlation coefficient assessed the correlation between the counted respiratory rate measurements and reference measurement. A Bland-Altman plot was used to assess systematic differences between the GP and reference measurements. 2x2 contingency tables were calculated at the cut-off value of ≥22 breaths per minute for both the counted and estimated respiratory rate measurements.

The interviews were summarised based on notes taken during the interview, and illustrative quotes were written down in full. Subsequently, the interviews were coded in AtlasTi version 8.2.29.0. The codes were organised based on the topics of the interview.

RESULTS

We included observations of 35 different GPs, of whom 14 were also interviewed. 18/35 (51%) of the GPs were female, and the mean working experience was 16 years. In total, 164 home visits for any medical reason were performed by the 35 GPs. Of these home visits, 130 observations of acutely ill adult patients were included in the analyses (range of one to seven observations per GP). The excluded contacts concerned determination of death (17), children (3) and patients who were not acutely ill (14).

In total, in 33/130 (25%) of the included patient contacts, the respiratory rate was counted for at least 15 seconds by the GP. At the GP cooperative in Ede, the respiratory rate was counted in 12/56 (21%) of the patients. Of the remaining 44 patient observations, an estimated respiratory rate (≥22

breaths per minute or not) was recorded. At the GP cooperatives in Den Bosch and Uden, in 21/74 (28%) of the patient contacts, the GP had counted the respiratory rate, and in 4 cases an estimation was recorded. Table 2 shows the patients' background characteristics in whom the respiratory rate was counted for at least 15 seconds, compared to the remaining included patients. The median age was 79 years in both groups, with respiratory complaints as the most common reason for the home visit. According to the reference measurement, the mean respiratory rate in the group in which the GP counted the respiratory rate was 21 breaths per minute, compared to 20 breaths per minute in the remaining patients.

Accuracy of the respiratory rate measurement

In Figure 1, the correlation of the counted respiratory rate measurements of the GPs and the reference measurement are shown. The Pearson's correlation coefficient was 0.91. There was no significant systematic difference between the GP- and reference measurement, as shown in the Bland-Altman plot in Figure 2. A mean difference of 0.27 (95% CI -5.7 to 6.3) breaths per minute was found, and 28/33 (85%) of the observations were within a margin of error of ≤ 2 breaths per min. Contingency tables of both the counted and estimated respiratory rates at a cut-off point of 22 breaths per minute are shown in Table 2. Compared to the reference measurement, the sensitivity for the observation of a respiratory rate ≥22 breaths per minute was 86% (95% CI, 57-98%) in patients for whom GPs counted the respiratory rate and 43% (95% CI, 23-66%) in patients for whom GPs estimated the respiratory rate. We found a specificity of 100% (95% CI 83-100%) for the counted observations and 96% (95% CI 81-100%) for the estimated observations.

Results of the interviews

All 14 interviewed GPs reported assessing the respiratory rate in practice, although some of them reported this as (very) infrequent. None of the GPs performed the measurements routinely in all

acutely ill patients. A reported method used to count the respiratory rate was observing thorax excursions for 15-30 seconds, with or without simultaneous palpation of the pulse. Other methods reported by the GPs are lung sound auscultation or palpation of the thorax. Mentioned clinical scenarios to measure the respiratory rate were adult patients with respiratory complaints, suspected infection, and acutely ill children. Other mentioned reasons to measure the respiratory rate were the clinical handover concerning patients referred to the hospital, to objectify shortness of breath, and to complete the overall clinical assessment.

"You often measure the respiratory rate in really sick patients or patients with dyspnea. "[GP8, F, 14y experience]

"It is improbable that the respiration rate influences patient management. In children, on the other hand, I do assess the respiratory rate sometimes." [GP7, F, 18y experience]

Most interviewed GPs use the respiratory rate with other clinical findings in their final assessment. Reasons not to measure the respiratory rate in all patients can be divided into medical and practical concerns. Most GPs find other vital signs more helpful in their assessment. Especially the peripheral oxygen saturation is often found sufficient for assessing breathing. Other medical reasons not to measure the respiratory rate are the chance of an abnormal finding without clinical relevance or the feeling it will not change patient management.

"I combine the respiratory rate with other vital signs and use that to decide how I treat the patient." [GP5, M, 38y experience]

"Since I use a pulse oximeter, I seldom measure the respiratory rate anymore, as this [the oxygen saturation] provides me with the information I need." [GP6, M, 30y experience]

Practical concerns are the difficulty of counting the respiratory rate in patients who keep talking or are moving or wear hindering clothes. Also, the needed investment of time was mentioned to play a role in the decision whether to count the respiratory rate.

"It can be difficult to measure the respiratory rate accurately. You should invest the time for it, and that is not always possible." [GP1, F, 12y experience]

DISCUSSION

Summary

In the setting of out of-hours home visits of acutely ill adult patients, GPs counted the respiratory rate during one in four consultations. These counted measurements were found to be accurate. In cases where the respiratory rate was not counted, the rate was often underestimated. A respiratory rate of ≥22 breaths per minute, as used in the qSOFA score, was not noticed in about half of the cases in which the GP did not count the respiratory rate. Based on the GP interviews, respiratory complaints and fever were the most important reasons GPs assess the respiratory rate. The preferred method was to count thorax excursions for 30 seconds (with or without taking the pulse). Reasons not to count the respiratory rate were medical (e.g., believed to be less relevant for patient management than other vital signs) and practical (e.g., time investment, hindering clothes).

Strengths and limitations

The most important strength of this study is that we observed GPs during the actual assessment of acutely ill patients in their homes. This study design enabled us to obtain real-world data on the accuracy of the respiratory rate measurement in practice. Another strength is the simultaneous

qualitative research, which provided more insight into the feasibility for GPs to count the respiratory rate. Several limitations of the study should also be mentioned. First, the Hawthorn effect may have played an important role during the study. The frequency of measurement of the respiratory rate is probably not representative of the typical situation without the presence of a researcher. As the GPs agreed to participate in a study where the respiratory rate measurement was observed, we expect to have overestimated the frequency in which GPs count the respiratory rate. We believe our findings should be interpreted as indicating how often (and how accurate) the respiratory rate is measured at best. Also, we only focused on the respiratory rate measurements during out-of-hours home visits. This timeframe may not be representative of other primary care settings. However, while all GPs participating in the study also work in office hours, and it is likely assessment of patients in this setting will be done comparable to OOH. Secondly, results may differ between countries as local GP training programs probably influence the attitude towards the respiratory rate measurement. Furthermore, we used a 60 second count of a single researcher as reference measurement, which may differ from the true respiratory rate. However, this is not likely to have influenced the results, as differences between the reference measurement and GP counted rates were small. Finally, the number of patient observations was small, leading to wide confidence intervals of the estimated sensitivity of counted and estimated measurements. However, the finding of the low sensitivity for the estimated measurements is robust as the upper limit of the 95% CI is still low at 66%.

Comparison with existing literature

We could not find any previous studies on the accuracy of respiratory rate measurements in general practice. Latten and colleagues, however, assessed the accuracy of the respiratory rate assessment by medical professionals, including GPs, based on video observations.[12] Overall, 78% of the observations were within a margin of error of 4 breaths per min, and the accuracy of the GP measurement was comparable to other healthcare professionals. The overall misclassification for the qSOFA was 8.9%. We found a somewhat lower misclassification in 2/33 (6%) of the patients for the qSOFA when the GP counted the respiratory rate.

In a study conducted in the ED in the Netherlands, assessments of adult medical patients were observed to assess how the ABCDE approach was applied in practice. The ABCDE approach was used in 26% of the patients. In case the ABCDE approach was used, this included measuring the respiratory rate in 92%. These study results are comparable to the results we found, but it should be noted that in the ED, vital signs were already measured during triage prior to the physician's assessment. Also, the respiratory rate might be measured by the physician, not as part of the ABCDE assessment.

Several GPs interviewed in the study reasoned that the respiratory rate measurement could be replaced by oxygen saturation. However, increased metabolic need, acidosis and inflammation are the main drivers of the respiratory rate in sepsis and not decreased oxygenation.[13] Several questionnaire studies have been performed among clinicians working in the hospital setting, assessing the knowledge of nurses and physicians about pulse oximetry.[14] The limitations of reading of the peripheral oxygen saturation are poorly understood and 7-42% of the clinicians believed it provides information about the ventilation of the patient. Measurement of respiratory rate and oxygen saturation are complementary and should not be substituted by one another.[15]

Implications for research and practice

The finding that only in a minority of the undifferentiated acutely ill patients, GPs in the Netherlands currently measure the respiratory rate has several implications. Firstly, the potential signalling function of an increased respiratory rate as an early sign of shock or sepsis is not fully utilised. Secondly, implementing a sepsis score such as the qSOFA may be difficult, and scores of the qSOFA may not be accurate in the respiratory rate is estimated instead of counted. Education and training of GPs may improve the measurement of the respiratory rate. However, before more extensive efforts are undertaken to encourage respiratory rate measurement by all GPs, it should be proven beneficial. More research should be performed in the primary care setting to show the added value of recognising critically ill patients or improving outcomes.

Conclusion

GPs are aware of the importance of assessing the respiratory rate of acutely ill adult patients and can accurately count the frequency. However, the respiratory rate is not counted in most patients, and the rate is often underestimated in these cases, with important loss of sensitivity to detect a high respiratory rate.

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Competing interests

Rogier M Hopstaken declares to have received honoraria from Lumiradx, Photondelta, and Abbott for advisory board meetings and lecturing. Arthur RH van Zanten reports receiving honoraria for advisory board meetings, lectures, research, and travel expenses from Baxter, Cardinal Health, Danone-Nutricia, DIM3, Fresenius Kabi, Mermaid, Lyric, and Nestlé-Novartis. Theo JM Verheij participated in studies that were funded by the EU and partly by Biomerieux, Becton Dickinson, Janssen Pharmaceuticals, and Abbott (IMI projects). All other authors have declared no competing interests.

Ethical approval

The Ethical Research Committee of the Radboud University Medical Center Nijmegen was consulted and concluded that this study did not require ethical approval (file number 2018-4178).

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Table 1. Background characteristics of the included acutely ill patients (n=130), divided by patients in whom the GP did or did not count the respiratory rate for at least 15 seconds.

	Respiratory rate counted	
Variable	Yes (n=33)	No (n=97)
Age, median years (IQR[a])	79 (68-86)	79 (69-85)
Sex, No (%)		
Male	15 (45)	50 (52)
Female	18 (55)	47 (48)
Type of complaint, No (%)		
Respiratory	12 (36)	16 (16)
Infectious	6 (18)	11 (11)
General malaise	2 (6)	12 (12)
Cardiovascular	4 (12)	9 (9)
Gastro-intestinal	4 (12)	14 (14)
Trauma	2 (6)	14 (14)
Neurologic	2 (6)	6 (6)
Other	1 (3)	15 (15)
Urgency at triage, No (%)		
U1: response immediately	2 (6)	2 (2)
U2: response as quickly as possible	17 (52)	41 (42)
U3: response in a few hours	13 (39)	53 (55)
U4: response in 24 hours	1 (3)	1 (1)
Respiratory rate, mean (SD[b])	21 (7.3)	20 (6.4)
GP characteristics, No (%)		
Female sex	14 (42)	43 (44)
>10 years working experience	25 (76)	74 (76)

[a]interquartile range; [b]standard deviation

Table 2. Contingency tables of the assessment of the respiratory rate of the GP compared to the reference measurement at a cut-off of 22 breaths per minute. A. GP counted respiratory rate at least 15 seconds, and B. Estimated respiratory rate by the GP.

A

		Reference measurement		
		≥22/min	<22/min	Total
Counted by GP	≥22/min	12	0	12
	<22/min	2	19	21
	Total	14	19	33

B

		Reference measurement		
		≥22/min	<22/min	Total
Estimated by GP	≥22/min	9	1	10
	<22/min	12	26	38
	Total	21	27	48

Figure 1. Correlation between the respiratory rate measurements of the GP (counted during at least 15 seconds) and the reference measurement.

Figure 2. Bland-Altman plot of the differences between the GP measurement of the respiratory rate and the reference measurement.