ORIGINAL ARTICLE

The Prognostic Significance of Respiratory Rate in Patients With Pneumonia

A retrospective analysis of data from 705 928 hospitalized patients in Germany from 2010–2012

Richard Strauß, Santiago Ewig, Klaus Richter, Thomas König, Günther Heller, Torsten T. Bauer

SUMMARY

Background: Measurement of the respiratory rate is an important instrument for assessing the severity of acute disease. The respiratory rate is often not measured in routine practice because its clinical utility is inadequately appreciated. In Germany, documentation of the respiratory rate is obligatory when a patient with pneumonia is hospitalized. This fact has enabled us to study the prognostic significance of the respiratory rate in reference to a large medical database.

Methods: We retrospectively analyzed data from the external quality-assurance program for community-acquired pneumonia for the years 2010–2012. All patients aged 18 years or older who were not mechanically ventilated on admission were included in the analysis. Logistic regression was used to determine the significance of the respiratory rate as a risk factor for in-hospital mortality.

Results: 705 928 patients were admitted to the hospital with community-acquired pneumonia (incidence: 3.5 cases per 1000 adults per year). The in-hospital mortality of these patients was 13.1% (92 227 persons). The plot of mortality as a function of respiratory rate on admission was U-shaped and slanted to the right, with the lowest mortality at a respiratory rate of 20/min on admission. If patients with a respiratory rate of 12–20/min are used as a baseline for comparison, patients with a respiratory rate of 27–33/min had an odds ratio (OR) of 1.72 for in-hospital death, and those with a respiratory rate above 33/min had an OR of 2.55. Further independent risk factors for in-hospital death were age, admission from a nursing home, hospital, or rehabilitation facility, chronic bedridden state, disorientation, systolic blood pressure, and pulse pressure.

Conclusion: Respiratory rate is an independent risk marker for in-hospital mortality in community-acquired pneumonia. It should be measured when patients are admitted to the hospital with pneumonia and other acute conditions.

► Cite this as:

Strauss R, Ewig S, Richter K, König T, Heller G, Bauer TT: The prognostic significance of respiratory rate in patients with pneumonia—a retrospective analysis of data from 705 928 hospitalized patients in Germany from 2010–2012. *Dtsch Arztebl Int* 2014; 111: 503–8.
DOI: 10.3238/arztebl.2014.0503

Measuring the respiratory rate is an important and simple tool for assessing the severity of acute cardiorespiratory and metabolic diseases.

The first British Thoracic Society survey (1982–1983) on prognostic factors for community-acquired pneumonia revealed a close association between respiratory rate and mortality (1). The mortality in this study rose from 0 for a respiratory rate below 20/min to 1.7%, 9% and 16% for respiratory rate values in the ranges 20 to 29, 30 to 39, and 40 to 49, respectively (1). The prognostic significance of the respiratory rate was confirmed in numerous studies about acute respiratory infections in different age groups (2–5). Accordingly, the respiratory rate is included in standard prognostic tools, such as the CRB 65 Index (confusion, respiratory rate, blood pressure, age ≥ 65 years) or the Pneumonia Severity Index (PSI or FINE Score) (6, 7). Although the German and international guidelines recommend the use of these scores (8–10), the respiratory rate is often not recorded in acute care situations, or the need for monitoring the respiratory rate is questioned (11–15). The main reason for that is the lack of awareness of the prognostic significance of this vital sign (13–15).

Since the introduction of mandatory external quality assurance in 2005, the respiratory rate of patients with community-acquired pneumonia is recorded on admission and on discharge. The objective of this analysis is to study the prognostic significance of the respiratory rate based on the external quality assurance data collected from an unselected patient population with community-acquired pneumonia.

Methods

Data of the mandatory external quality assurance from 2010 to 2012 in the clinical area *Community-acquired pneumonia* were analyzed. The data set includes all adults (≥ 18 years) who received inpatient treatment in a German hospital with the principal diagnosis of community-acquired pneumonia. Patients were identified based on the ICD code of the DRG (*Diagnose-bezogene Fallgruppen*, German Diagnosis-Related Groups) coding with pneumonia as principal diagnosis (*eBox 1*). Patients with severe immunodeficiency (such as leukemia or HIV infection) and hospital-acquired

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TABLE 1

Frequency distribution of the respiratory rate on admission in the patient population studied

Respiratory rate on admission (in 1/min)	Frequency	Percentage
below 12	4059	0.6
12–20	308 964	48.2
21–23	84 248	13.1
24–26	118 212	18.4
27–33	97 472	15.2
above 33	28 706	4.5
total	641 661	100.0

pneumonias (*eBox 2*) were excluded. Data were collected on type of admission (from nursing facility, hospital or rehabilitation facility), bedridden state, state of consciousness, respiratory rate and blood pressure on hospital admission (*eFigure 1*). The method how to measure the respiratory rate or the procedure is not prescribed. The breaths should be counted over a period of at least 30 seconds, ideally of one minute. In the 2010 data year, logistic regressions were first introduced to promote fair risk comparison (for example between hospitals), taking into consideration (nearly) all patients admitted with community-acquired pneumonia. With this method, the impact of the respiratory rate can be analyzed while simultaneously taking into account/adjusting other prognostic factors. Based on this approach, the following risk-adjusted analyses were performed (16).

To evaluate the respiratory rate on admission as a risk factor for hospital mortality, a logistic regression was performed including all patients (≥ 18 years) who did not receive mechanical ventilation at the time of admission. Adjustments were performed on the following parameters: age, sex, admission from nursing facility, hospital or rehabilitation facility, bedridden state, state of consciousness, and blood pressure on hospital admission. Calculation of the hospital standardized mortality ratio (HSMR) in relation to respiratory rate was based on these risk factors used in the model. These were included in the standardization with the respective regression coefficient. Patients without records of the respiratory rate and/or the blood pressure on admission, patients with implausible blood pressure values (< 20 mmHg) and respiratory rates (< 6 /min or > 49 /min) were excluded.

Statistical analysis was performed using IBM SPSS 20.0.0.

Results

Between 2010 and 2012, altogether 705 928 adult patients were treated on an in-patient basis for community acquired pneumonia. With 67.1 million adults (≥ 18 years) living in Germany, this represents an average annual incidence of hospital admissions for pneumonia

of 3.5 per 1000 inhabitants above 18 years. Of these patients, 13.1% (92 277) died during their hospital stays. 692 950 patients were not ventilated on admission. For 643 356 of the remaining patients, admission respiratory rate data were available; of these, 641 661 patients had plausible values, i.e. an admission respiratory rate between 6/min and 49/min and a systolic blood pressure of more than 20 mmHg. Of these evaluable 641 661 patients, 80 293 died (12.5%).

About half of these patients had respiratory rates between 12 and 20/min (normal range). Less than 1% had values below 12/min (*Table 1*). The hospital standardized mortality ratio (HSMR) of the patients in relation to the respiratory rate shows a right-skewed U-shaped distribution, with the lowest probability of dying at about 20/min (*Figure 1*). In a binomial logistic regression analysis of the 2010–2012 data, the admission respiratory rate was one of several independent risk factors for hospital mortality. The risk of dying significantly increases on both admission respiratory rates above 20/min and below 12/min (*Figure 2*). The odds ratio for patients with respiratory rates:

- between 21 and 23/min is 1.20
- between 24 and 26/min is 1.33
- between 27 and 33/min is 1.72 and
- above 33/min is 2.55 in comparison with patients with respiratory rates between 12 and 20/min.

Other independent risk factors are age, admission from nursing facility, hospital or rehabilitation facility, chronic bedridden state, disorientation, systolic blood pressure and pulse amplitude (*Table 2*).

Discussion

Respiratory rate and prognosis in pneumonia

With over 230 000 hospital admissions per year, community-acquired pneumonia is one of the most common acute conditions in German hospitals. More than 10% of these patients die during their hospital stay (www.sgg.de/ergebnisse/leistungsbereiche/ambulant-erworbene-pneumonie.html). Due to the large numbers and the high mortality among these patients, an early and rather simple prognostic assessment is required. Measuring the respiratory rate on admission is well suited for early risk stratification: Both decreased and increased respiratory rates on admission are associated with significantly increased hospital mortality rates. A comparatively mild tachypnea of 21–23/min already yields an odds ratio of 1.20 (95% CI: 1.17–1.23). The risk of dying rises further with increasing respiratory rate: with respiratory rates above 33/min the odds ratio is 2.55 (*Table 2*).

This relationship between mortality and respiratory rate on admission was first reported in a survey of the British Thoracic Society with 453 pneumonia patients which was published in 1987 (1). It can also be demonstrated in Germany (*Figure*).

The respiratory rate is an integral part of established prognostic tools such as the CRB-65 index or the PSI (6,7). Measuring the respiratory rate for calculating the CRB-65 index is also recommended in the S3 guideline

for outpatient patients with pneumonia to help with the decision whether a patient should be admitted to hospital (recommendation level B) (8). In the external quality assurance for *Community-acquired pneumonia*, the documentation of the respiratory rate is required for the calculation of the CRB-65 index, among others, and thus for risk adjustment. Without reliable documentation of the respiratory rate, risk adjustment via the CRB-65 index cannot be performed. Moreover, with missing or incorrect documentation the respiratory rate is lost as a parameter for developing future risk adjustment tools.

Respiratory rate as marker of acute disease

In acute bronchial asthma, pulmonary embolism or heart failure, the respiratory rate is an important prognostic parameter as well (17–19). Because hypercapnia, hypoxia and metabolic acidosis, amongst others, lead to an increase in respiratory rate, it is logical that the respiratory rate can be used to detect and monitor these conditions, regardless of the underlying disease. Therefore, measuring the respiratory rate may support the early identification of high-risk patients. This was demonstrated for patients in emergency departments, in general wards or after surgery (20–24). For example, the respiratory rate was the parameter best suited to identify high-risk patients among 1695 emergency department patients (25). Likewise, in the prediction of cardiac arrest on a general ward, the respiratory rate was superior to other physiological parameters, such as hypoxia and systolic blood pressure (26, 27). Interestingly, a recently published analysis of more than a million sets of vital data of patients in a US hospital found an association between the deviation of the respiratory rate from normal and hospital mortality of a size similar to that demonstrated for the external quality assurance pneumonia data (Figure) (28). In early warning systems, which trigger the deployment of hospital emergency teams, measuring the respiratory rate is regularly included and again one of the best predictive parameters (11, 20, 23, 25). If the respiratory rate is not measured, these tools cannot be used or the alarm threshold is not reached. Thus, abnormal respiratory rates should be further investigated while these patients require close monitoring (e.g. on display devices).

Measuring of respiratory rate

The most commonly used method to determine the respiratory rate is discontinuous manual measurement by counting the respiratory chest movements (via inspection or auscultation). In adult patients, the respiratory rate can also be measured manually with sufficient reliability (good intra- and inter-observer reliability) (29, 30). Taking into consideration the variability of breathing, a period of at least 30 seconds should be allowed for measuring. Even more accurate results can be obtained by counting the respiratory rate over a period of 60 seconds or in two blocks of 30 second intervals (31). Capnography, the measurement of CO₂ concentrations in the expired air, is considered

The lowest mortality rate is found at a respiratory rate of 20/min. The hospital mortality increases above and below the normal range of respiratory rate (12–20/min). Therefore, this relationship is better represented by LOWESS regression than linear regression.

the gold standard of continuous monitoring. Alternative technologies include impedance pneumography (recording of chest impedance changes during in- and expiration by means of chest wall electrodes) or the detection of breathing-induced amplitude modulation of R-waves in electrocardiography (ECG), among others. Impedance pneumography is commonly used along with continuous ECG monitoring; measurements are reliable as long as interfering factors, such as wrong electrode placement, coughing or excessive patient movements, are excluded (32).

Limitations

One important limitation of the study is the diagnosis of community-acquired pneumonia using the coded principal diagnosis and the exclusion of hospital-acquired pneumonias and pneumonias associated with severe immunodeficiency using coded secondary diagnoses. Pneumonia patients coded with another principal diagnosis (e.g. sepsis) may have been missed, while patients with hospital-acquired pneumonias or severe immunodeficiency may have been included if the secondary diagnosis was not coded. The impact of comorbidities could not be included in the analysis of independent risk factors for hospital mortality as these were not systematically recorded with this method. This is one of the reasons why the adjustment only has a moderate Nagelkerke's pseudo-R².

The validity of the analyzed data depends on the validity of the measuring method and the quality of documentation. While for parameters such as age or survival a high level of validity can be expected, a higher error rate has to be assumed for the measurement

TABLE 2

Independent risk factors for hospital mortality*

Risk variable		Wald	Odds Ratio	95% confidence interval	
				lower limit	upper limit
Age	62 to 72 years	2027	2.34	2.26	2.43
	73 to 79 years	3564	2.97	2.86	3.08
	80 to 85 years	5384	3.71	3.58	3.84
	above 85 years	7303	4.58	4.42	4.74
Respiratory rate on admission	below 12/min	56	1.44	1.31	1.59
	21–23/min	190	1.20	1.17	1.23
	24–26/min	655	1.33	1.30	1.36
	27–33/min	2394	1.72	1.69	1.76
	above 33/min	3423	2.55	2.47	2.63
Systolic blood pressure on admission	up to 110 mmHg	5979	2.21	2.16	2.25
	111–120 mmHg	356	1.28	1.25	1.31
	121–134 mmHg	67	1.11	1.08	1.14
Pulse amplitude up to 40 mmHg		111	1.11	1.09	1.14
Male sex		452	1.20	1.18	1.22
Admission from inpatient nursing facility		189	1.15	1.13	1.17
Admission from other hospital or inpatient rehabilitation facility		118	1.25	1.20	1.30
Chronic bedridden status		6457	2.28	2.23	2.32
Disorientation unrelated to pneumonia		2249	1.69	1.65	1.73
Disorientation related to pneumonia		6939	2.91	2.84	2.99

*according to logistic regression, in hospital-treated patients with pneumonia (2010–2012: N = 641 661, of that 80 293 hospital deaths).
Reference categories: respiratory rate 12–20/min, age < 62 years, systolic blood pressure on admission > 134 mmHg.
Area under the ROC curve: 0.78
Nagelkerke's pseudo-R²: 0.20

and documentation of the respiratory rate, for example. With more than 200 000 data sets per year from over 1200 hospitals, reviewing individual cases is not possible. Thus, implausible values or values under 6/min or above 49/min which, based on clinical experience, are rather difficult to measure accurately were excluded from this study. In the actual quality assurance program, statistical abnormality identification with feedback to the affected hospitals (“structured dialogue”) and random sampling with second acquisition of selected data fields were used for data validation. Moreover, with quality assurance in the clinical area *Pneumonia* in place since 2005, the participants were familiar with it. A particular strength of this study is that virtually all hospitalized patients in Germany with community-acquired pneumonia were included.

Potential for improvement and conclusion

Measuring the respiratory rate is a simple and reliable tool to assess the prognosis in patients with pneumonia and other acute diseases.

Studies and also the discussion related to the external quality assurance in the clinical area *Pneumonia*

show that measuring and documenting the respiratory rate is still not generally accepted (11–15).

To improve the measurement and documentation of vital signs in general and of the respiratory rate in particular, more awareness of their proven importance for patient care should be raised among nurses and doctors during their education and training. Training to this effect has been proven to result in significant improvements. For example, training and audits as part of the implementation of an “early-warning system” on general wards increased the level of respiratory rate documentation from 30% to 91%, while in an emergency department environment, vital signs documentation climbed from 78% to 88% (33, 34).

Conflict of interest statement

All authors are members of the Federal Experts' Working Group on Pneumonia of the AQUA Institute.

PD Strauß has received fees for consultancy from Swedish Orphan Biovitrum, Biotest and Pfizer. He has received reimbursements for congress participation fees from Bayer Vital, Pfizer and InfetcoPharm. He has received reimbursement for travel and accommodation expenses and fees for the preparation of scientific meetings from Bayer Vital, Pfizer, InfetcoPharm, and MSD.

The remaining authors declare that no conflict of interest exists.

Manuscript received on: 18 September 2012; revised version accepted on 15 May 2014.

Translated from the original German by Ralf Thoene, MD.

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KEY MESSAGES

- The frequency of respiratory rate is a key prognostic parameter in community-acquired pneumonia.
- Its significance in pneumonia and other acute diseases is generally underestimated in clinical practice. Thus, the respiratory rate is often not measured and adequately documented.
- In all acute cases, measurement and documentation of the respiratory rate should not be limited to the initial physical examination, but repeated over the course of the hospital stay. Patients with increased respiratory rates should be closely monitored (e.g. on display devices) to ensure vital function disturbances are detected and treated early.
- Without reliable measurement and documentation of the respiratory rate, many prognostic or risk assessment tools cannot be used.
- Measuring the respiratory rate should be as routine as measuring the pulse and blood pressure.
- Efforts to increase awareness of the significance of the respiratory rate should be stepped up and training in correct measurement and documentation should be intensified.

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eBOX 1

ICD Codes of Inclusion Diagnoses

A48.1 Legionnaires disease
 B01.2 Varicella pneumonia
 J10.0 Influenza with pneumonia, other influenza virus identified
 J11.0 Influenza with pneumonia, virus not identified
 J12.0 Adenoviral pneumonia
 J12.1 Respiratory syncytial virus pneumonia
 J12.2 Parainfluenza virus pneumonia
J12.3 (new) Human metapneumovirus pneumonia
 J12.8 Other viral pneumonia
 J12.9 Viral pneumonia, unspecified
 J13 Pneumonia due to *Streptococcus pneumoniae*
 J14 Pneumonia due to *Haemophilus influenzae*
 J15.0 Pneumonia due to *Klebsiella pneumoniae*
 J15.1 Pneumonia due to *Pseudomonas*
 J15.2 Pneumonia due to staphylococcus
 J15.3 Pneumonia due to streptococcus, group B
 J15.4 Pneumonia due to other streptococci
 J15.5 Pneumonia due to *Escherichia coli*
 J15.6 Pneumonia due to other aerobic Gram-negative bacteria
 J15.7 Pneumonia due to *Mycoplasma pneumoniae*
 J15.8 Other bacterial pneumonia
 J15.9 Bacterial pneumonia, unspecified
 J16.0 Chlamydial pneumonia
 J16.8 Pneumonia due to other specified infectious organisms
 J18.0 Bronchopneumonia, unspecified
 J18.1 Lobar pneumonia, unspecified
 J18.2 Hypostatic pneumonia, unspecified
 J18.8 Other pneumonia, organism unspecified
 J18.9 Pneumonia, unspecified
 J69.0 Pneumonitis due to food and vomit
 J85.1 Abscess of lung with pneumonia

eBOX 2

ICD Codes of Exclusion Diagnoses

B20 Human immunodeficiency virus [HIV] disease resulting in infectious and parasitic diseases
 B21 Human immunodeficiency virus [HIV] disease resulting in malignant neoplasms
 B22 Human immunodeficiency virus [HIV] disease resulting in other specified diseases
 B23.0 Acute HIV infection syndrome
 B23.8 HIV disease resulting in other specified conditions
 B24 Unspecified human immunodeficiency virus [HIV] disease
 C81.0 Nodular lymphocyte predominant Hodgkin lymphoma
 C81.1 Nodular sclerosis classical Hodgkin lymphoma
 C81.2 Mixed cellularity classical Hodgkin lymphoma
 C81.3 Lymphocyte depleted classical Hodgkin lymphoma
 C81.7 Other classical Hodgkin lymphoma
 C81.9 Hodgkin lymphoma, unspecified
 C82.0 Follicular lymphoma grade I
 C82.1 Follicular lymphoma grade II
 C82.2 Follicular lymphoma grade III, unspecified
 C82.7 Other types of follicular lymphoma
 C82.9 Follicular lymphoma, unspecified
 C83.0 Non-follicular lymphoma: Small cell (diffuse)
 C83.1 Non-follicular lymphoma: Small cell, cleaved (diffuse)
 C83.2 Non-follicular lymphoma: Mixed small and large cell (diffuse)
 C83.3 Non-follicular lymphoma: Large cell (diffuse)
 C83.4 Non-follicular lymphoma: Immunoblastic (diffuse)
 C83.5 Non-follicular lymphoma: Lymphoblastic (diffuse)
 C83.6 Non-follicular lymphoma: Undifferentiated (diffuse)
 C83.7 Burkitt lymphoma
 C83.8 Other non-follicular lymphoma
 C83.9 Non-follicular (diffuse) lymphoma, unspecified
 C84.0 Mycosis fungoides
 C84.1 Sézary's disease
 C84.2 T-zone lymphoma
 C84.3 Lymphoepithelioid lymphoma Lennert's lymphoma
 C84.4 Peripheral T-cell lymphoma
 C84.5 Other mature T/NK-cell lymphomas
 C85.0 Lymphosarcoma
 C85.1 B-cell lymphoma, unspecified
 C85.7 Other specified types of non-Hodgkin's lymphoma
 C85.9 Non-Hodgkin's lymphoma, unspecified type
 C88.00 Waldenström's macroglobulinaemia: Without information about complete remission
 C88.10 Alpha heavy chain disease: Without information about complete remission
 C88.20 Gamma heavy chain disease: Without information about complete remission
 C88.30 Immunoproliferative small intestinal disease: Without information about complete remission
 C88.70 Other malignant immunoproliferative diseases: Without information about complete remission
 C88.90 Malignant immunoproliferative disease, unspecified: Without information about complete remission
 C90.00 Plasmacytoma [Multiple myeloma]: Without information about complete remission

C90.10 Plasma cell leukemia: Without information about complete remission
 C90.20 Plasmacytoma, extramedullary: Without information about complete remission
 C91.00 Acute lymphoblastic leukemia: Without information about complete remission
 C91.10 Chronic lymphatic leukemia: Without information about complete remission
 C91.20 Subacute lymphatic leukemia: Without information about complete remission
 C91.30 Polymphocytic leukemia: Without information about complete remission
 C91.40 Hairy-cell leukemia: Without information about complete remission
 C91.50 Adult T-cell leukemia: Without information about complete remission
 C91.70 Other lymphoid leukemia: Without information about complete remission
 C91.90 Lymphoid leukemia, unspecified: Without information about complete remission
 C92.00 Acute myeloid leukemia: Without information about complete remission
 C92.10 Chronic myeloid leukemia: Without information about complete remission
 C92.20 Subacute myeloid leukemia: Without information about complete remission
 C92.30 Myeloid sarcoma: Without information about complete remission
 C92.40 Acute promyelocytic leukemia: Without information about complete remission
 C92.50 Acute myelomonocytic leukemia: Without information about complete remission
 C92.70 Other myeloid leukemia: Without information about complete remission
 C92.90 Myeloid leukemia, unspecified: Without information about complete remission
 C93.00 Acute monocytic leukemia: Without information about complete remission
 C93.10 Chronic monocytic leukemia: Without information about complete remission
 C93.20 Subacute monocytic leukemia: Without information about complete remission
 C93.70 Other monocytic leukemia: Without information about complete remission
 C93.90 Monocytic leukemia, unspecified: Without information about complete remission
 C94.00 Acute erythremia and erythroleukemia: Without information about complete remission
 C94.10 Chronic erythremia: Without information about complete remission
 C94.20 Acute megakaryoblastic leukemia: Without information about complete remission
 C94.30 Mast cell leukemia: Without information about complete remission
 C94.40 Acute panmyelosis: Without information about complete remission
 C94.50 Acute myelofibrosis: Without information about complete remission
 C94.70 Other specified leukemias: Without information about complete remission
 C95.00 Acute leukemia of unspecified cell type: Without information about complete remission
 C95.10 Chronic leukemia of unspecified cell type: Without information about complete remission
 C95.20 Subacute leukemia of unspecified cell type: Without information about complete remission
 C95.70 Other leukemia of unspecified cell type: Without information about complete remission
 C95.90 Leukemia, unspecified: Without information about complete remission
 C96.0 Letterer-Siwe disease
 C96.1 Malignant histiocytosis
 C96.2 Malignant mast cell tumor
 C96.3 True histiocytic lymphoma
 C96.7 Other specified malignant neoplasms of lymphoid, hematopoietic and related tissue
 C96.9 Malignant neoplasm of lymphoid, hematopoietic and related tissue, unspecified
 D70.0 Congenital agranulocytosis and neutropenia
 D70.10 Drug-induced agranulocytosis and neutropenia: Critical period less than 4 days
 D70.11 Drug-induced agranulocytosis and neutropenia: Critical period from 10 to less than 20 days
 D70.12 Drug-induced agranulocytosis and neutropenia: Critical period 20 days and more
D70.13 (New) drug-induced agranulocytosis and neutropenia: Critical period from 4 to less than 7 days
D70.14 (New) drug-induced agranulocytosis and neutropenia: Critical period from 7 to less than 10 days

D70.18 Other types of drug-induced agranulocytosis and neutropenia
D70.19 Drug-induced agranulocytosis and neutropenia, unspecified:
D70.3 Other agranulocytosis
D70.5 Cyclic neutropenia
D70.6 Other neutropenia
D70.7 Neutropenia, unspecified
D71 Functional disorders of polymorphonuclear neutrophils
D72.0 Genetic anomalies of leukocytes
D76.00 Multifocal Langerhans cell histiocytosis
D76.01 Unifocal Langerhans cell histiocytosis
D76.08 Other and unspecified Langerhans cell histiocytosis, not elsewhere classified
D76.1 Hemophagocytic lymphohistiocytosis
D76.2 Hemophagocytic syndrome, infection-associated
D76.3 Other histiocytosis syndromes
D80.0 Hereditary hypogammaglobulinemia
D80.1 Nonfamilial hypogammaglobulinemia
D81.0 Severe combined immunodeficiency [SCID] with reticular dysgenesis
D81.1 Severe combined immunodeficiency [SCID] with low T- and B-cell numbers
D81.2 Severe combined immunodeficiency [SCID] with low or normal B-cell numbers
D81.3 Adenosine deaminase [ADA] deficiency
D81.4 Nezelof syndrome
D81.5 Purine nucleoside phosphorylase [PNP] deficiency
D81.6 Major histocompatibility complex class I deficiency
D81.7 Major histocompatibility complex class II deficiency
D81.8 Other combined immunodeficiencies
D81.9 Combined immunodeficiency, unspecified
D82.0 Wiskott-Aldrich syndrome
D82.1 Di-George syndrome
D82.2 Immunodeficiency with short-limbed stature
D82.3 Immunodeficiency following hereditary defective response to Epstein-Barr virus
D82.8 Immunodeficiency associated with other specified major defects
D82.9 Immunodeficiency associated with major defect, unspecified
D83.0 Common variable immunodeficiency with predominant abnormalities of B-cell numbers and function
D83.1 Common variable immunodeficiency with predominant immunoregulatory T-cell disorders
D83.2 Common variable immunodeficiency with autoantibodies to B- or T-cells
D83.8 Other common variable immunodeficiencies
D83.9 Common variable immunodeficiency, unspecified
D84.0 Lymphocyte function antigen-1 [LFA-1] defect
D84.1 Defects in the complement system
D90 Immunocompromisation after radiation, chemotherapy and other immunosuppressive measures
T86.00 Failure of transplanted hematopoietic stem cells
T86.01 Acute Graft-versus-host disease, grade I and II
T86.02 Acute Graft-versus-host disease, grade III and IV
T86.03 Chronic Graft-versus-host disease, limited form
T86.04 Chronic Graft-versus-host disease, distinct form
T86.09 Graft-versus-host disease, unspecified
T86.10 Acute deterioration in kidney transplant function

T86.11 Chronic deterioration in kidney transplant function
T86.12 Delayed start of transplant function
T86.19 Other and unspecified functional impairment, failure and rejection of a kidney transplant
T86.2 Failure and rejection of heart transplant
T86.3 Failure and rejection of heart and lung transplant
T86.40 Acute deterioration in liver transplant function
T86.41 Chronic deterioration in liver transplant function
T86.49 Other and unspecified functional impairment, failure and rejection of a liver transplant
T86.81 Failure and rejection: Lung transplant
T86.82 Failure and rejection: Pancreas transplant
U69.00 Elsewhere classified, hospital-acquired pneumonia in patients aged 18 years and older
Z94.0 Kidney transplant status
Z94.1 Heart transplant status
Z94.2 Lung transplant status
Z94.3 Heart and lung transplant status
Z94.4 Liver transplant status
Z94.80 Hematopoietic stem cell transplant status, without presence of immunosuppression
Z94.81 Hematopoietic stem cell transplant status, with presence of immunosuppression
Z94.88 Other transplanted organ and tissue status