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Does inappropriate selectivity in information use relate to diagnostic errors and patient harm? *The diagnosis of patients with dyspnea*

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Abstract

Background:

Physicians often take shortcuts in diagnostic reasoning by being selective in the information that they gather and follow-up on. Although necessary, these shortcuts are susceptible to cognitive biases and may cause diagnostic errors. The aim of this study is to examine the occurrence of inappropriate selectivity in information-gathering and information-processing in the diagnostic process and study how it relates to diagnostic errors and patient harm.

Methods:

Expert internists reviewed the patient records of 247 dyspnea patients to detect reasoning faults, diagnostic errors and patient harm. The cases with reasoning faults were discussed with the treating physicians. Based on the record review and the clarifications from the treating physicians, the occurrence of inappropriate selectivity in information-gathering and information-processing was established and related to the occurrence of diagnostic errors and patient harm.

Results:

Inappropriate selectivity in the diagnostic reasoning process occurred in 45.7% (113 of 247) of the cases. Specifically, selective information-gathering occurred in 33.2% of the cases and selective information-processing in 12.6% of the cases. Diagnostic errors occurred in 18.3% of the cases with selective information-gathering, and in 35.5% of the cases with selective information-processing. Patient harm occurred in 11.0% of the cases with selective information-gathering and in 38.7% of the cases with selective information-processing.

Conclusions:

The results showed that inappropriate selectivity in the diagnostic process occurred in a substantial number of cases. Particularly inappropriate selective information-processing was related to diagnostic errors and patient harm. Prevention strategies should include an increase in promoting the falsification strategies in the diagnostic process.

Background

The diagnostic reasoning process is a complex process that involves many different decision making skills. Since diagnostic errors are often considered to be preventable and severe, it is an important topic in the field of patient safety.[1-3] Many different factors are involved in the occurrence of diagnostic errors, such as lack of knowledge and atypical presentation of the disease.[3-6] In addition, cognitive biases are often mentioned as a cause of diagnostic error.[7-9] Cognitive biases are faulty beliefs that affect decision making and occur because physicians use heuristics during the diagnostic process.[8,10,11] Heuristics are shortcuts in the reasoning process, which means that not all available information is used to come to a diagnosis.[12] These heuristics are necessary to diagnose a patient within a reasonable amount of time and without conducting many unnecessary diagnostic tests. Heuristics are usually associated with fast diagnostic reasoning, and in most cases with correct diagnoses.[13,14] Actually, the use of heuristics in the diagnostic process, can even lead to better diagnoses.[12] Particularly experts are able to diagnose a patient after gathering little data because they rely on the heuristic of pattern recognition.[15]

Although the use of heuristics is important in diagnostic reasoning, they may lead to cognitive biases which can lead to faulty data-gathering and faulty data-synthesis and diagnostic errors.[16] For example, when the physician focuses on a specific diagnosis based on his/her recent experiences, and as a consequence does not adequately evaluate the evidence pointing towards alternatives (availability bias).[9,17,18] Research showed that many cognitive biases occur in diagnostic reasoning and that they occur at all levels of expertise.[19-22] The common denominator of the cognitive biases is that physicians are too selective in their reasoning process and therefore overlook likely diagnoses. This selectivity is inappropriate, which may result in a diagnostic error when relevant information is missed.[8] Inappropriate selectivity may have serious consequences depending on the stage of the diagnostic process in which it occurs and strategies to prevent inappropriate selectivity should be adapted to the specific stage [7,23] Inappropriate selectivity in clinical practice and the situations in which it leads to diagnostic error and patient harm has not been studied extensively.[6]

This study aims to determine 1. the occurrence of inappropriate selectivity in the information-gathering and information-processing stages of the diagnostic reasoning process of dyspnea patients and 2. to what extent inappropriate selectivity in the diagnostic reasoning process is related to diagnostic error and patient harm in clinical practice.

Method

Patient record reviews in combination with interviews with the treating physicians were used to determine the occurrence of inappropriate selectivity, the stages of the process in which selectivity occurred and the occurrence of diagnostic error and patient harm. See Figure 1 for an overview of the data-gathering process of the study.

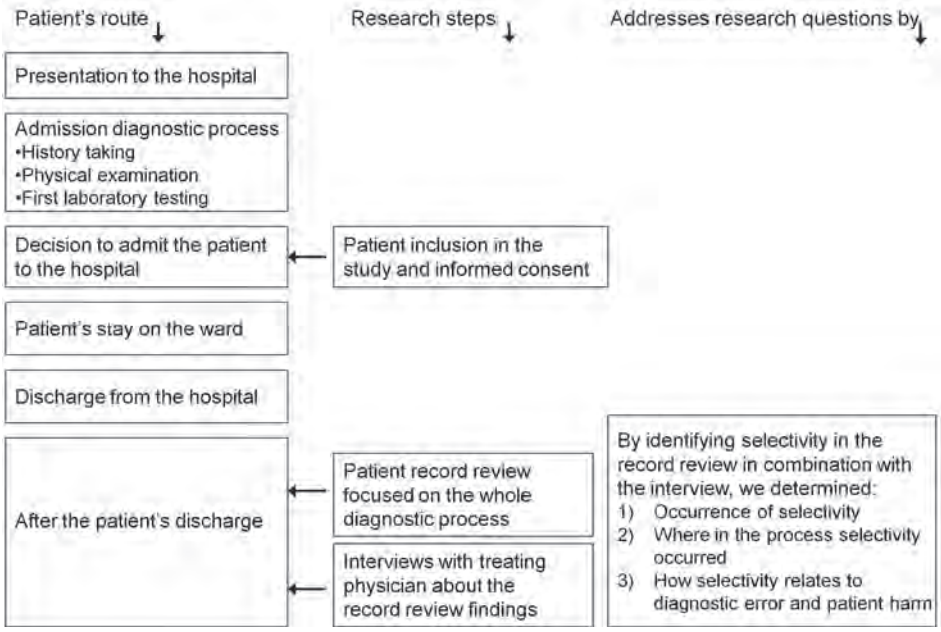

Figure 1. Overview of the patient's route, the steps of the study and the addressed research questions.

Patient selection

Five acute care hospitals in the Netherlands (one university hospital, two tertiary teaching hospitals and two general hospitals) participated in the study. The start of the study was phased for practical reasons meaning that after the data-gathering process was set-up in one hospital, the next hospital started the inclusion of patients. The hospitals started about a month after each other and every hospital participated 6-8 months between May 2007 and February 2008. The study took place in seven departments of internal medicine, cardiology and pulmonology (in some hospitals the departments worked closely together and therefore both participated in the study). All eligible consecutive patients admitted to the hospital with dyspnea (shortness of breath) or who developed dyspnea during their hospital

stay were included by the treating physicians. By selecting dyspnea patients, we selected a homogenous patient group that has not been studied extensively in the field of diagnostic error. A total of 261 patients were included in the study of which 14 records were lost. Possible reasons for the missing records involve for example incorrect registration of the location of the patient record by the archive. Therefore, 247 patients are described in this study.

Record review

Optimal diagnostic process

Since there was no guideline available in the Dutch handbook for diagnostic guidelines for the diagnostic process when starting with dyspnea as a symptom, a two-staged Delphi method with seven experienced internists was used to determine the optimal diagnostic process for dyspnea patients. We selected internists who had recently retired and who met the following criteria: they 1. had at least 10 years of post-graduate work experience in internal medicine, 2. a good reputation amongst colleagues, 3. had retired for no longer than 5 years at the time of selection as a reviewer.

The goal of the Delphi study was to determine the steps that had to be considered while diagnosing a dyspnea patient, such as considering the recent medical history and involving the information of previous health care professionals. Two meetings were organized to develop the optimal diagnostic process based on cases of dyspnea patients filled out by the reviewers. All internists approved of the final version of the optimal diagnostic process.

Reviewers

Four expert internists, who also participated in the Delphi study, participated in the record review process. Based on this optimal process the record review questionnaire to study the diagnostic reasoning process was developed by the researcher in collaboration with the internist reviewers. The participating internists attended a training program (2 days) about the study protocol, the review questionnaire and the computer program in which the questionnaire was programmed. After having reviewed several records, another training session was organized to discuss questions and difficulties.

Review process and questionnaire

After the patients were discharged from the hospital and informed consent was obtained, their patient records were reviewed, identifying faults in the diagnostic

reasoning process. Because of the large variety of diagnoses among patients presenting with dyspnea, we relied on the clinical expertise of the expert internist reviewers to determine whether faults occurred. The internist reviewers also took the clinical context into account when reviewing the patient records. These reasoning faults were suboptimal decisions that contributed or could have contributed to the occurrence of a diagnostic error such as incomplete data gathering or incorrect interpretation of a test result. The record review also identified diagnostic errors, i.e. a diagnosis that was unintentionally delayed, wrong or missed as judged from the eventual appreciation of more definitive information.[16]

The record review questionnaire assessed all steps of the diagnostic process. The information-gathering stage involved: history taking, physical examination, laboratory requests and imaging techniques. The information-processing stage existed of: the interpretation of the results found in the information-gathering stage, outlining a diagnosis, starting the treatment and verification of diagnosis and treatment during the patient's stay. For the information-gathering stages the review questionnaire first inquired whether all aspects that were considered to be relevant according to the optimal diagnostic process and the clinical expertise of the reviewers (such as family history, EKG, D-dimer) were identified or checked by the treating physician. If an aspect was considered to be relevant by the reviewer, but not checked/performed by the treating physician, this was considered a fault in the information-gathering stage. For the information-processing stages the treating physician's interpretation of the findings was assessed i.e. whether correct conclusions were drawn from the findings. If the reviewers considered the interpretation by the treating physician to be incorrect, this was considered to be a fault in the information processing stage. By studying the information gathering and information interpretation stages thoroughly while often having access to more definitive information such as the patient record of a subsequent hospital admission, the internist reviewers determined whether a diagnostic error occurred. In some cases it was not possible to determine the correct diagnosis if the treating physician did not gather sufficient information to establish a diagnosis with certainty. These cases were defined as most likely a diagnostic error, but in the analysis included as diagnostic errors. For the reasoning faults as well as the diagnostic errors additional questions were answered about (possible) patient harm (any disadvantage for the patient that leads to prolonged or strengthened treatment, temporary or permanent impairment or death).[24]

An inter-rater reliability study was conducted in which 25 randomly selected cases were reviewed by two out of the four reviewers. The reliability between the reviewers for the determination of patient harm was fair, (κ = 0.34; 95% CI 0.0 to

1.0; 88% agreement). For the determination whether the diagnosis was correct or incorrect, the reliability was moderate, (κ = 0.51; 95% CI 0.06 to 0.95; 84% agreement). The reliability for the reasoning faults was fair, (κ = 0.28; 95% CI 0.00 to 0.76; 76% agreement).[25]
This study is part of a larger study and a more detailed description of the method can be found in the design paper and the results of the occurrence of reasoning faults is published elsewhere.[25,26]

Interviews with treating physicians

A researcher (LZ) interviewed the treating physicians about the presumed reasoning faults that they were involved in. The interviews completed the information that was missing from the patient record. We were able to conduct an interview with 48 out of the 58 residents that were involved in reasoning faults. A total of 144 of the 163 cases with faults were discussed. 19 interviews (11%) were missing because the treating physician could not be contacted for the interview.[25] The goal of the interview was to find out the causes of the faults and to verify whether there was another reason for the occurrence of the fault that was not described in the patient record. The interviews consisted of clear-cut questions such as: "Pulmonary embolism was a possible diagnosis, why did you decide not to conduct any further tests to establish or rule out PE?" or "Why did you decide not to perform an EKG to check for heart rhythm disorder?" The answers of the treating physicians were checked with the expert record reviewer to determine whether the fault was still valid. Both the record review and the answers of the treating physicians about the faults were used to evaluate whether inappropriate selectivity in information use occurred.

Determining inappropriate selectivity in diagnostic reasoning

Inappropriate selectivity in the diagnostic reasoning process was defined as: cases in which a probable diagnosis (as judged by the reviewer) was not sufficiently considered and therefore not confirmed or ruled out. The cases were examined using three steps:

1. The cases in which faults were found in the information-gathering and/or information-processing stages in the record review were selected.
2. By using the findings in the record review and the interview with the treating physician, LZ (research psychologist) and AT (internist) evaluated whether the faults involved inappropriate selectivity i.e. for each patient case it was evaluated whether all probable diagnoses (according to the record reviewers) were

sufficiently considered to be confirmed or ruled out. Faults in which a diagnosis was insufficiently precise (e.g. the type of pneumonia was not established) or faults indicating that a diagnosis that should have been established following different diagnostic criteria (e.g. an immediate CTa to confirm pulmonary embolism without a preceding (less invasive) D-dimer), were not considered to be inappropriate selectivity because the diagnoses were considered.

3. In the information-gathering stage all faults identified by the reviewers, were checked with the treating physicians and based on their answer categorized as inappropriate selectivity or not. For example, a fault in the information-gathering stage such as "the physician did not apply for a d-dimer when pulmonary embolism was likely", could have the following answer from the treating physician: "I did not consider PE as a likely option". This was considered as inappropriate selectivity. While the following answer: "I did perform a d-dimer test, but I do not write down a non-deviating test result in the patient record" was considered a fault in the information gathering stage, but not due to inappropriate selectivity because the treating physician did consider pulmonary embolism. When the physician was not available for an interview, LZ and AT determined whether inappropriate selectivity took place based on the record review only.
4. The information-processing stage was distinguished into two different types of inappropriate selective information-processing: Selective information-integration and selective review of test results. Selective information-integration was defined as: inappropriate selective integration and/or interpretation of the gathered information while forming the working diagnosis, thus the treating physician did not use all relevant information while determining the diagnosis according to the reviewers. Selective interpretation of the test results was categorized as such if the treating physician did not follow up on deviation laboratory and other test results needed to confirm or rule out a diagnosis according to the reviewers.

If in one case both selective information-gathering and selective information-processing occurred, for simplicity we classified this hierarchically as selective information-processing. The two types of selective information-processing did not co-occur.

Statistical analysis

Descriptive statistics were used for most of the analyses. To compare the occurrence of diagnostic error and patient harm in cases with versus without the

different types of inappropriate selectivity χ^2 tests and tests for comparison of proportions in two independent samples were used, for all tests the continuity correction was applied.

Confidentiality and ethical approval

The ethical review board of the VU University Medical Centre approved of the research protocol, and all participating hospitals granted approval to participate. The internist reviewers and researchers involved in the data collection signed a confidentiality agreement to maintain the secrecy of the data. Patients included in the study gave informed consent to review their patient record.

Results

Patient sample

The patient characteristics are described in Table 1.

Physicians

The physicians who included the patients in the study and who were interviewed involved 72 medical residents who were supervised by a medical specialist. The residents had on average 29 months (SD= 26.5) of work experience.

Inappropriate selective diagnostic reasoning

The record review revealed faults in the diagnostic process of 66.0% (163 of 247) of the included dyspnea patients.[25] In 69.3% of the faults it involved inappropriate selectivity. Of the total number of cases, in 45.7% (113 of 247 cases) inappropriate selective information-gathering or inappropriate selective information processing took place. This involved selective information-gathering in 33.2% (82 of 247) of the cases while selective information-processing was identified in 12.6% (31 of 247) of the cases (see Table 2). Within the information-processing stage, selective information-integration involved 4.9% (12 of 247) of the cases while selective interpretation of test results occurred in 7.7% (19 of 247) of the cases. For examples of the cases, see Table 3.

Table 1. Patient characteristics (N=247)[25]

Male patients	**115 (46.6%)**
Average age (SD)	**69.9 (14.9)**
Median length of stay in days (inter quartile range)	**10 (11)**
Correct diagnosis	
1. Heart failure	**51 (20.6%)**
2. Chronic obstructive pulmonary disease/Bronchitis/Asthma	**59 (23.8%)**
3. Pneumonia	**47 (19.0%)**
4. Malignancy	**16 (6.5%)**
5. Pulmonary embolism	**14 (5.7%)**
6. No diagnosis	**3 (1,2%)**
7. Other (e.g: meningitis, cholecystitis, anemia, septic shock, pneumothorax, viral infection, hyperventilation, hepatorenal syndrome, bronchiolitis, pancreatitis)	**57 (23.1%)**
Relevant co-morbidity (can be more than one diagnosis per patient)	**116 (51%)**
1. Heart failure	**18 (15,5%)**
2. Atrial fibrillation	**15 (12.9%)**
3. Pneumonia	**13 (11.2%)**
4. Chronic obstructive pulmonary disease/Bronchitis/Asthma	**20 (17.3%)**
5. Renal insufficiency	**11 (9.5%)**
6. Ischemic heart disease without heart failure	**11 (9.5%)**
7. Malignancy	**8 (6.9%)**
8. hypoglycemia	**9 (7.8%)**
9. Anemia	**5 (4.3%)**
10. Other (e.g: aorta valve stenosis, meningitis, septic shock, viral infection, lung fibrosis, urinary tract infection, liver failure, HIV, hypertension, pulmonary embolism, thrombosis)	**74 (63.8%)**

Table 2. Occurrence and consequences of inappropriate selective information-gathering and information-processing as determined by the record review

	Cases	Cases with diagnostic error	Cases with patient harm
Inappropriate selective information-gathering	82 (33.2%)	18.3% (15 out of 82) 95%CI: 10-27% *	11.0% (9 out of 82) 95%CI: 4-18%
inappropriate selective information-processing: interpretation of test results	19 (7.7%)	26.3% (5 out of 19) 95%CI: 7-46%	42.1% (8 out of 19)* 95%CI: 20-64%
Inappropriate selective information-processing: information-integration	12 (4.9%)	50% (6 out of 12)* 95%CI: 22-78%	33,3% (4 out of 12)* 95%CI: 7-60%
No inappropriate selectivity	134 (54.2%)	6.0% (8 out of 134) 95%CI: 2-10%	5.2% (7 out of 134) 95%CI: 1-9%

* Significantly more diagnostic errors or patient harm when compared to cases without inappropriate selectivity; p< 0.01

Table 3. Examples of inappropriate selective information-gathering and information-processing

	Examples including short explanation of the physician
Inappropriate selective information-gathering	The patient's history suggested pulmonary embolism (patient with breast cancer and previous pulmonary embolisms), however no information was gathered nor tests were performed to determine this. The physician said he/she considered pneumonia was more likely and decided it was not necessary to examine pulmonary embolism as well. For patient with an exacerbation of COPD, heart failure was not investigated while likely (no check for oedema and central venous pressure, no CT thorax). The physician explained that this patient came to the hospital regularly and always had an exacerbation of COPD and therefore did not examine her further. Breast examination was not performed while relevant because of a possible breast carcinoma. The physician indicated that since the patient came with a abdominal problem he/she considered it not necessary to examine the breasts as well.
Inappropriate selective information-processing: Information-integration	In a patient with both pneumonia and heart failure, the heart failure was missed. The physician did not consider heart failure as a possibility while the patients' recent medical history included mitral insufficiency and atrial fibrillation. The physician realized during the interview that his/her diagnostic process was focused on confirming pneumonia and therefore he/she completely overlooked the possibility that heart failure was also present. Cholescystitis was missed because of incorrect interpretation of abdominal pain and the patient's history. The physician said that urosepsis was a plausible explanation for the patients' symptoms and complaints and therefore did not consider cholescystitis. A lung tumor was initially missed, while it was detectable on the CT thorax. Although the patient's condition did not substantially improve no control CT thorax was ordered and no other diagnoses were considered and explored. The physician did not consider a tumor since the complaints of the patient were pointing towards her heart. The physician therefore considered the main problem to be cardiac.
Inappropriate selective information processing: interpretation of test results	Laboratory results showed anaemia (low hemoglobin levels), which was not further investigated. The physician explained that since the results of the tests were not available immediately he/she forgot to look at them later. Cholangitis with sepsis was missed. The physician explained that the patient did not arrive at the hospital with abdominal pain, but presented with symptoms of bronchitis. The laboratory results were abnormal later in the process and the physician did not notice this. He/she thinks he/she should have been more alert and should have noticed and followed-up on this abnormality. Liver abnormalities were not further investigated. The physician said that when he/she is working in the department of cardiology he/she is focused on the heart. Therefore, he/she does not specifically examine laboratory results not related to the main (heart) problem.
No inappropriate selectivity	A sputum test was conducted for a patient with a suspicion of pneumonia. The test was conducted after giving antibiotics to the patient. Therefore the test result was not reliable and the patient was treated with unnecessary antibiotics. A patient had overload disease, which was not detected by the physician. The physician considered it, but it was not recognized in the CT thorax. The diagnosis of COPD was initially missed. This is a complex diagnosis to detect and everything was done correctly to examine the patient and the information was interpreted correctly. After 5 days the correct diagnosis was established.

Diagnostic error and patient harm

Diagnostic errors occurred in 34 of 247 cases (13.8%) and in 28 of 247 cases (11.3%) the patient was harmed. In 8 of 247 cases (3.2%) a diagnostic error occurred and the patient was harmed.[25] Cases in which the record review revealed inappropriate selectivity (N=113), diagnostic errors and patient harm occurred more often when compared to cases without inappropriate selectivity (diagnostic error 23.0% vs 6.0%: $\chi^2(1) = 13.6$; p= <0.001; patient harm 18.6% vs 5.2%: $\chi^2(1)=9.6$; p= <0.01).

When specifying the types of inappropriate selectivity (see also Table 2.), we found that diagnostic errors occurred significantly more often in cases with selective information-gathering compared to cases without selectivity. There was no significant difference in the occurrence of patient harm. Both diagnostic error and patient harm occurred significantly more often in cases with selective information-processing when compared to cases without selectivity (diagnostic error 35.4 vs 6%, z= 4.31, p<0.01; patient harm 38.7 vs 5.2, z= 4.96, p<0.01). In cases with selective interpretation of test results diagnostic errors did not occur significantly more often than in cases without selectivity, but patient harm did (See table 2.)

DISCUSSION

Inappropriate selective information-gathering and inappropriate selective information-processing occurred frequently in the diagnostic reasoning process and were associated with the occurrence of more diagnostic errors and patient harm when compared to cases without inappropriate selectivity. Inappropriate selective information-gathering occurred more often than inappropriate selective information-processing. However a higher percentage of cases with selective information-processing as compared to selective information-gathering seemed associated with adverse outcomes, i.e. selective information-integration was associated with both diagnostic error and patient harm and selective interpretation of test results was associated with patient harm.

There are some limitations of this study. First, during the record review, we rely on the retrospective judgment of the expert internists. Although they were well trained and had extensive experience in the medical field, subjectivity as well as hindsight bias might have had an effect on the data. Second, the evaluation of inappropriate selectivity was based on the record review and the interview with the treating physician. Since it was a retrospective explanation of the reasoning faults their answers might be different from what actually happened. Furthermore, the

final evaluation of inappropriate selectivity was based on the review of the patient's case by an internist and a research psychologist and might therefore be influenced by subjectivity as well, although we tried to make the evaluation procedure as explicit as possible. Thirdly, the patient records could not always provide a definitive measure of a diagnostic error. Therefore, the occurrence of a diagnostic error could not always be established with certainty. Lastly, due to the rather small number of cases with inappropriate selectivity (particularly in the information-processing stages), the conclusions should be interpreted with caution.

Inappropriate selective information-gathering was shown to occur frequently, but was related to a diagnostic error or patient harm in a minority of the cases. One explanation for the inappropriate selectivity in this stage of the diagnostic process is that physicians make a rational decision, based on the costs and benefits of gathering more information. Most of the information is gathered early in the process, which is probably the stage of the diagnostic process in which fast decision-making is most important. Gathering limited information will save valuable time, and physicians may reason that the benefit of gathering more data is small, since the most likely diagnoses are already examined. Another explanation is that physicians gather information too strongly in light of their existing hypotheses. They may gather information that supports their hypothesis while information about alternative diagnoses is not gathered. Fortunately, in most cases inappropriate selectivity in the information-gathering stages did not lead to diagnostic errors or patient harm. This is in contrast with inappropriate selectivity in the Information-processing stages, which was related to diagnostic error and patient harm more often. Inappropriate selectivity was probably more severe in the information-processing stage of the diagnostic process because the a-priori probability that the information was relevant is higher in this stage. In the information-gathering stages, physicians gather information related to the most likely diagnoses, while in the information processing stages the information that was not processed was considered to be important earlier in the process.

Selectivity in the information-processing stages may occur because the physician might have already established a working diagnosis and may therefore have insufficiently considered the information suggestive of alternative diagnoses,[27] due to e.g. overconfidence and premature closure.[9,23] Physicians are more likely to confirm their existing ideas than changing them.[27,28] Inappropriate selectivity can also occur due to incorrectly valuing the information that is gathered. Physicians adapt their ideas about the importance of information based on the context.[6] Information consistent with their working diagnosis is more easily considered

to have important diagnostic value, while inconsistent information is more easily evaluated as having little diagnostic value.[6] This particularly accounts for the interpretation of laboratory results, because the results of (some of the) laboratory tests arrive after the physician has established a firm differential diagnosis. In accordance with this study, studies of Singh et al showed that for many patients who were diagnosed with colon cancer or lung cancer, an abnormal test result had been available earlier in the process [29,30]. While the studies of Singh et al were retrospective, the present study demonstrated that these abnormalities could be detected earlier in the process before knowing the outcome if the test results were considered and valued correctly.

To improve the diagnostic reasoning process and reduce the occurrence of diagnostic error and patient harm, two types of prevention strategies could be helpful. First, to reduce the incorrect considerations of physicians (i.e. incorrect cost-benefit considerations in information-gathering, and incorrectly valuing the available information during the information-processing stage), more systematic feedback may be useful. Physicians can learn from their own incorrect considerations. This should be systematically integrated in the diagnostic process, e.g. discussing it more specifically during moments of supervision and handovers. Second, to reduce the effect of cognitive biases (i.e. not gathering or processing data that do not match the existing hypotheses), the application of falsification strategies is potentially helpful. Research on logical reasoning has shown that in order to consider a statement as correct, the hypotheses should be confirmed and at the same time alternatives should be ruled out. Verification of the hypothesis is insufficient and thus a combination of a verification and falsification strategies is needed.[31] Thus in diagnostic reasoning, it is important to verify whether the established diagnosis can explain all of the main complaints and symptoms. At the same time, alternative diagnoses should be considered. Physicians should use more falsification of alternative diagnoses to reduce diagnostic errors and patient harm. Particularly, review of available information could be a relatively simple way to detect possible (other) relevant information that should be followed up. This includes considering the presence of co-morbidity. Furthermore, more research to study if the occurrence of inappropriate selectivity, the development of intervention strategies and their effects is needed.

Conclusions

Inappropriate selectivity in the diagnostic reasoning process occurs frequently and is related to diagnostic error and patient harm, this seems to account

particularly for inappropriate selectivity in the information-processing stages of the diagnostic process. In order to improve diagnostic reasoning and reduce the occurrence of diagnostic errors and patient harm systematic feedback during supervision and handovers could be helpful. Furthermore, more falsifying reasoning strategies may help to detect a correct diagnosis or co-morbidity.

Reference List

(1) Leape LL, Brennan TA, Laird N et al. The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. *N Engl J Med.* 1991;324:377-384.

(2) Baker GR, Norton PG, Flintoft V et al. The Canadian Adverse Events Study: the incidence of adverse events among hospital patients in Canada. *CMAJ.* 2004;170:1678-1686.

(3) Zwaan L, De Bruijne MC, Wagner C et al. A record review on the incidence, consequences and causes of diagnostic adverse events. *Arch Intern Med.* 2010;170:1015-1021.

(4) Neale G, Woloshynowych M, Vincent C. Exploring the causes of adverse events in NHS hospital practice. *J R Soc Med.* 2001;94:322-330.

(5) Schiff GD, Hasan O, Kim S et al. Diagnostic Error in Medicine: Analysis of 583 Physician-Reported Errors. *Arch Intern Med.* 2009;169:1881-1887.

(6) Kostopoulou O, Mousoulis C, Delaney BC. Information search and information distortion in the diagnosis of an ambiguous presentation. *Judgment and Decision Making.* 2009;4:408-418.

(7) Croskerry P. The importance of cognitive errors in diagnosis and strategies to minimize them. *Acad Med.* 2003;78:775-780.

(8) Elstein A.S. Heuristics and Biases: selected errors in clinical reasoning. *Acad Med.* 1999;74:791-794.

(9) Berner ES, Graber ML. Overconfidence as a cause of diagnostic error in medicine. *Am J Med.* 2008;121:S2-23.

(10) Tversky A, Kahneman D. Judgment under uncertainty: Heuristics and biases - Biases in judgments reveal some heuristics of thinking under uncertainty. *Science.* 1974;185:1124-1131.

(11) Bornstein BH, Emler AC. Rationality in medical decision making: a review of the literature on doctors' decision-making biases. *J Eval Clin Pract.* 2001;7:97-107.

(12) Wegwarth O, Gaissmaier W, Gigenrenzer G. Smart strategies for doctors and doctors-in-training: heuristics in medicine. *Med Educ.* 2009;43:721-728.

(13) *Harrison's principles of internal medicine*. 17 ed. McGraw-Hill Professional; 2008.

(14) JM O. *Sapira's Art and Science of Bedside Diagnosis*. 4 ed. Lippincott Williams & Wilkins; 2009.

(15) Groves M, O'Rourke P, Alexander H. Clinical reasoning: the relative contribution of identification, interpretation and hypothesis errors to misdiagnosis. *Med Teach.* 2003;25:621-625.

(16) Graber ML, Franklin N, Gordon R. Diagnostic error in internal medicine. *Arch Intern Med.* 2005;165:1493-1499.

(17) Berner ES, Maisiak RS, Heuderbert GR, Young KR, Jr. Clinician performance and prominence of diagnoses displayed by a clinical diagnostic decision support system. *AMIA Annu Symp Proc.* 2003;76-80.

(18) Graber M. Diagnostic errors in medicine: a case of neglect. *Jt Comm J Qual Patient Saf.* 2005;31:106-113.

(19) Voytovich A, Rippey R, Suffredini A. Premature Conclusions in Diagnostic Reasoning. *J Med Educ.* 1985;60:302-307.

(20) Dubeau C, Voytovich A, Rippey R. Premature Conclusions in the Diagnosis of Iron-deficiency Anemia: Cause and Effect. *Med Decis Making.* 1986;6:169-173.

(21) Redelmeier DA. Improving patient care. The cognitive psychology of missed diagnoses. *Ann Intern Med.* 2005;142:115-120.
(22) Graber M, Gordon R, Franklin N. Reducing diagnostic errors in medicine: what's the goal? *Acad Med.* 2002;77:981-992.
(23) Kempainen RR, Migeon MB, Wolf FM. Understanding our mistakes: a primer on errors in clinical reasoning. *Med Teach.* 2003;25:177-181.
(24) Zegers M, De Bruijne MC, Wagner C et al. Adverse events and potentially preventable deaths in Dutch hospitals: results of a retrospective patient record review study. *Qual Saf Health Care.* 2009;18:297-302.
(25) Zwaan L, Thijs A, Wagner C, Van der Wal G, Timmermans D. Relating faults in diagnostic reasoning with diagnostic errors and patient harm. *Acad Med*. In press.
(26) Zwaan L, Thijs A, Wagner C, Van der Wal G, Timmermans DRM. Design of a study on suboptimal cognitive acts in the diagnostic process, the effect on patient outcomes and the influence of workload, fatigue and experience of physicians. *BMC Health Services Research.* 2009;9.
(27) Russo J, Husted Medvec V, Meloy M. The Distortion of Information during Decisions. *Organizational Bahavior and Human Decision Processes.* 1996;66:102-110.
(28) Simon D, Snow C, Read S. The Redux of Cognitive Consistency Theories: Evidence Judgments by Constraint Satisfaction. *Journal of Personality and Social Psychology.* 2004;86:814-837.
(29) Singh H, Daci K, Petersen LA et al. Missed opportunities to initiate endoscopic evaluation for colorectal cancer diagnosis. *Am J Gastroenterol.* 2009;104:2543-2554.
(30) Singh H, Hirani K, Kadiyala H et al. Characteristics and predictors of missed opportunities in lung cancer diagnosis: an electronic health record-based study. *J Clin Oncol.* 2010;28:3307-3315.
(31) Johnson-Laird P, Wason P. A Theoretical Analysis of Insight into a Reasoning Task. *Cognitive Psychology.* 1970;1:134-148.