How to limit clinical errors in interpretation of data

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We all assume that we can understand and correctly interpret what we read. However, interpretation is a collection of subtle processes that are easily influenced by poor presentation or wording of information. This article examines how evidence-based principles of information design can be applied to medical records to enhance clinical understanding and accuracy in interpretation of the detailed data that they contain.

The previous paper showed how careful design can make information within records easier to find. The focus in this paper is on how design can assist correct interpretation and thereby limit clinical errors. Unfortunately, repeated encounters with medical records have desensitised doctors to the poor presentation of information. For example, in one study clinicians considered their records satisfactory even when objective measures, such as speed in retrieving specific details of patients, indicated much room for improvement.

The ease with which written materials can be used to check details or make decisions is strongly influenced by how the content is visually presented, and in many professional domains errors result from poor information design. Errors in interpretation of words, tables, or graphs result from the cognitive processes of perception, attention, and memory, which operate in similar ways for everyone. So, although some of the evidence we cite comes from studies unrelated to medical care, it applies equally to use of medical records.

Perception, attention, and memory

A familiar example of interpretation difficulties resulting from perception is illegible handwriting or type on computer screens or printouts. These perceptual difficulties can lead to confusion over drug names (for example, Norflex and Norflox). Type is usually more legible than handwriting, but this advantage can be lost if the writer uses too many different fonts, colours, or embellishments such as italics, all capital letters, or underlining. Errors in interpretation of words, tables, or graphs result from the cognitive processes of perception, attention, and memory, which operate in similar ways for everyone. So, although some of the evidence we cite comes from studies unrelated to medical care, it applies equally to use of medical records.

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practitioners in the Netherlands, where doctors in urban practices found information in their records more easily than did doctors in rural practices. Those in rural practices are probably happier not to record consultations in full detail because they have fewer patients and the population is more static.

### Interpretation of textual data

#### Visual factors

Records can be structured by means of informative headings, columns, and vertical and horizontal space or lines. Visual structure, discussed in the previous paper, makes data easier to find. It also aids interpretation because record structure provides a context that makes data less ambiguous (panel 1). Enhanced visual structure benefits printed or electronic documents containing either textual or numeric data: figure 1 shows how data become easier to interpret as the amount of visual structure increases.

#### Clarity of language

Text entries in medical records must be succinct, but must also avoid ambiguity. The note, “Pain in left knee—not sitting” may be concise and clear to the writer, but to other readers it could mean that the pain disappears when the patient sits or that, because of pain, the patient is not sitting. If, while entering data, writers anticipate the needs of readers, there can be benefits in speed and accuracy for future users, including the original writer.

Ambiguities can also arise with quantifiers such as “sometimes” or “often”, because these convey different meanings to patients and clinicians, with patients tending to attribute higher frequencies. Ambiguity is lessened if frequency is explicitly specified—for example, as “once a month”. Similarity, use of ill-defined words (eg, large, likely) to quantify size or probability, is best avoided. The different interpretation by doctors of alternative, equivalent measures of drug efficacy, such as absolute and relative difference, is a further warning that words matter.

People are more error-prone when text involves negatives, whether the negative is explicit (not, un-, ex-) or implicit (less, shorter, smaller). Because of the way language skills develop from infancy, people find comparisons phrased positively—“the lesion on the left is longer than that on the right”—easier to understand than those phrased negatively—“the lesion on the right is shorter than that on the left”. In many cases the positive information is also more succinct (“Still smoking” rather than “Has not stopped smoking”). The safest way to use negatives in records is to denote it by means of informative headings (eg, “Pain in left knee”) rather than by phrasing negatively—“the lesion on the left”—easy to understand than those phrased negatively—“the lesion on the right is shorter than that on the left”.

Another example of how wording can generate bias is the “framing effect”, which resembles the shift in perception from judging a glass to be half-full to judging it half-empty. The reality is unchanged, but the different perspective encourages different actions. In a study of researchers given simulated interim results of a clinical trial, the same data were presented to some researchers as treatment failure rates and to others as success rates; the proportion who made the correct decision about whether to stop the trial early was twice as high when the data were presented as failure rates. In terms of medical records, when a progress note reads “The oedema has gone down”, the implied action may be to do nothing further. However, if the note reads “Significant oedema remains”, a change in the treatment may seem appropriate. Although not as succinct, presentation of both perspectives “The oedema has gone down but significant oedema remains” can reduce errors of interpretation.

#### Interpretation of numeric data

Numeric data occur frequently in medical records, so should be segregated in a separate column (figure 1). If there are many numeric data, from multiple investigations or repeated observations, a table or graph will help. Graphs make trends more explicit, and well-designed tables make location of specific data items easier. However, doctors differ in how they define data items such as duration of illness, which may be

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**Sample clinical questions**

- When was the fracture last X-rayed?
- Is the rate of recovery satisfactory?
- Is this patient accident prone?

**Helpful design features**

- Appropriate document structure, including informative headings
- Consistent location for specific categories of information—eg, dates, laboratory results
- Verbal summaries of non-verbal data
- Consistency in data formats
- Time-lines
- Positive wording
- Highlighting of relevant data
- List of patient’s previous diagnoses

**Little visual structure — a single heading and numerical data (nnn) included within continuous text**

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afgh dikafgh dikafgh dikafgh dikafgh dikafgh dikafgh dikafgh dikafgh dikafgh
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**Visual structure given by segmentation, subheadings, spatial alignment for specific data (eg, numerical values), and the visual cue** for abnormal values

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afgh dikafgh dikafgh dikafgh dikafgh dikafgh dikafgh dikafgh dikafgh dikafgh
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Figure 1: Effect of visual structure on ease of finding and interpretation of data

The four numerical values (nnn) that appear in each of the examples are easier to find and interpret as more visual structure is introduced into the record.

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**Panel 1: Design features that facilitate interpretation of data in medical records**

**Helpful design features**

- Appropriate document structure, including informative headings
- Consistent location for specific categories of information—eg, dates, laboratory results
- Verbal summaries of non-verbal data
- Consistency in data formats
- Time-lines
measured from symptom onset, clinical diagnosis, start of treatment, or laboratory confirmation. Also, clinicians do not all share conventions for the order of data in a table or form; options include ordering by date, by test type, or by test result. Use of columns and rows in tables with explicit headings removes the risk of misunderstanding.

For laboratory reports that show data in a table or graph, errors can arise when their design violates readers' expectations about how the data are organised. Graphs with missing or unclear axis labels will cause errors. People make fewer errors in reading data values off a graph when the scale divisions are multiples of two or ten than when other multiples are used. Differences in the proportions or aspect ratio of graphs can also influence interpretation. This effect was studied in obstetricians; the same cervical dilation data were plotted against time on partograms that had different aspect ratios (figure 2). The flatter graph (right-hand plot, aspect ratio 1:5) gave the visual impression that cervical dilation was taking place very slowly; doctors would have decided to intervene in twice as many patients (44 vs 19% of patients) as when the same data were shown on the taller graph (left-hand plot, aspect ratio 1:0). This was a careful laboratory study, but doctors had been trained with the taller

Figure 2: Effect on interpretation of dilation rate of choice of scale
Adapted from Cartmill and Thornton. The dilation rate appears slower in the right-hand plot, which has a bigger scale on the time axis.

Figure 3: Medical record summary formatted as a time-line for interventions and progress notes
Symbols can be expanded to a report or diagram. Modified and reproduced with permission from Plaisant and colleagues.
Panel 2: Six principles of information design that can aid interpretation of medical record data

Set the context
eg. Give the date and main purpose of the consultation.

Write informative headings
Rather than a generic heading “Symptoms”, use a more specific heading, “Eating problems”, to aid interpretation and future retrieval.

Limit the information given under each heading
Records with more subheadings, and fewer data under each, will be more easily used than the reverse.

Include signposts and landmarks within the records
These can be specific locations for certain kinds of information, or marking of abnormal values or adverse reactions with highlighter or marginal symbol.

Organise information to meet the needs of more than one profession
Visual separators, such as lines or boxes, can distinguish instructions to other professionals, such as clinic nurses, from data.

Make the organisation of the material visually explicit
Vertical space between sections and horizontal indents helps to signal the relation between different parts of a medical record.

Use of computers to aid interpretation
Graphs and tables are easily produced by a computer, but poorly designed graphs and tables in commercial and lab reports are designed. Improved record design will enable faster searches and more accurate interpretation, thereby improving outcomes for patients and reducing the costs of health care. Although the importance of many of the design factors we have discussed in this paper has been known for a long time, these factors seem to have had little influence on medical-record format and language.

Conclusions
In clinical practice, we need the right data on the right patient at the right time and in the right place. To interpret the data correctly, however, we also need the data in the right format and language. The format and language depend partly on how clinicians enter data in the record and partly on how documents such as laboratory reports are designed. Improved record design will enable faster searches and more accurate interpretation, thereby improving outcomes for patients and reducing the costs of health care. Although the importance of many of the design factors we have discussed in this paper has been known for a long time, these factors seem to have had little influence on medical-record format and language. Panel 2 summarises six principles of information design that can enhance data interpretation. Fuller discussion of how these and other principles can enhance medical communication are available.

The last paper in this series will examine the advantages and disadvantages of computerisation of medical records. Where does the balance currently lie? Do computer-based records benefit clinicians and patients, or interpose drawbacks and new design demands?

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