Paper-Based Patient Chart Design Information Sheet

The purpose of this document is to help those involved in creating paper-based patient charts improve the human factors aspects of the design of their charts. It is based on the outcomes of a research project ("Human Factors Research Regarding Observation Charts") carried out at the University of Queensland for the Australian Commission on Safety and Quality in Health Care, the Queensland Health Patient Safety and Quality Improvement Service and the Clinical Skills Development Service. Copies of the reports associated with this project are available online from the Commission's website (www.safetyandquality.gov.au). As part of this project, we systematically reviewed 25 existing patient observation charts and developed a new chart (the "ADDS chart") designed to identify patient deterioration, which was then evaluated in behavioural experiments. In this document, we will use some of the issues arising from this process to illustrate human factors design considerations for paper-based patient charts in general.

Read through each of the fourteen issues detailed below, considering their relevance for the design for your chart. ***Note that this information sheet is intended as an introductory guide to paper-based patient chart design and it is not sufficient to guarantee a good outcome.*** It is not designed to be a substitute for engaging a human factors specialist as part of your chart design team and any chart needs to go through the same systematic and rigorous design, evaluation, and testing process that is detailed in the project reports associated with the ADDS chart. ***It is not a trivial task to create a safe and user-friendly chart!***

1. What is the purpose of the chart? Does it contain any information not relevant to the job it was intended to do?

It is critical for the designer to have a clear idea of their chart's specific function. For example, the ADDS chart was developed with the specific goal of detecting patient deterioration. This had substantial design implications; for example, any information not essential to detecting patient deterioration was expunged from the chart, as people can only process a certain amount of information at once. If a chart contains extraneous information then that information will compete for the user's attention with other, more important, elements of the chart. This increases the risk that the indicators that really matter will be missed. It may also lead to individuals being forced to use more laborious search patterns while reading the chart, which could increase the time it takes them to identify relevant information, as well as decreasing their accuracy in identifying significant changes.

- Does your chart contain only the information critical to its purpose?
    - For example, you should remove or de-emphasize prominently-featured bureaucratic codes or hospital names/logos.

2. Is the most important information displayed in the most prominent way?

There are a number of different ways that information can be displayed to make it more likely to be noticed by users. For example, in the ADDS chart, we positioned what were considered to be the most important vital signs (as determined by reviewing the literature) for detecting patient deterioration at the top of the page, as this is where users are most likely to look first. Also the size of text and the use of bold or capitalized text can be used to give cues to relative importance (though capitals should be used sparingly as they slow reading).

- Does your chart prioritize the information it contains in the most appropriate manner?
    - While it might often be useful to place the most important information at the top of the chart, there may be reasons why other strategies might be more appropriate. For example, if the information has to be collected in a particular order then it may be best to present the information in this order on the chart.
    - You should avoid relying on historical precedent to determine the positioning of information in your chart if there is a better alternative.
    - Your chart should use visual cues (for example, boxing text) to separate different types of information. For example, information explaining how the chart is to be used should be separated from information about clinical issues.

3. Are different pieces of information, which a user might need to compare, in close proximity?

If there are two or more pieces of information on a chart that users need to compare, then these should be positioned close to one another on the page. For example, if a user has to refer over a page to a look up table, it will make the chart harder to use (as they may have to hold a number in memory while turning the page). In the ADDS chart, we ensured that all the vital signs were on the same page and that any look up tables were positioned as close to the data as possible. Note that on a paper-based chart, trade-offs may be required if there are competing demands on a particular piece of information. For example, you may want the information to be displayed close to a chart element that it needs to be compared with. At the same time, you may also want the information to be displayed at the top of the page for maximum prominence, which conflicts with the first requirement. This could mean that there is no perfect position for this information on the chart and the design solution may have to involve a trade-off. The effect of such trade-offs need to be tested (see point 14).

- Does your chart cluster information effectively? The following points are illustrative examples of this principle.

- You should place look up tables next to the data entry location in order to minimize search time and reduce row or column shift errors.
- You should organize information required for data interpretation into relevant groupings. For example, in the ADDS chart, respiratory rate and oxygen flow are located next to one another.

4. Is all necessary information easily accessible?

In the ADDS chart, we ensured that as much necessary information as possible was immediately available to users. This included action plans for what to do once a patient reached a certain level of deterioration, examples of how data were to be recorded, and prompts for how to use the alerting systems (see point 11 below).

- Does your chart contain all the information required to allow the user to enter data, interpret the data and conduct the right course of action?
  - For example, you should include any action requirements on the same page as the data that would drive the actions.

5. Is the chart likely to be legible under all conditions in which it is likely to be used?

You should evaluate all the conditions, under which you expect clinicians to enter and interpret data using your chart, for their effect on chart legibility. You also need to take into account the variability of eyesight in the healthcare workforce. For example, can your chart be read under poor lighting conditions by clinicians who have poor eyesight? Note that the issues listed below are only a subset of potential considerations, and requirements will vary depending upon the environment and the population of clinicians who will use your chart.

- Is your chart legible and is data entry user-friendly?
  - You should make the font sizes (including the spaces where users may have to write in information) large enough to be legible, especially under low light conditions. One rule of thumb is that the spaces provided to write information should be big enough to contain 14 point font printed text. Printed text on the chart should be no smaller than 11 point font.
  - The chart should be readable in realistic low-light conditions.
  - The chart should be legible for colour-blind clinicians.
  - If the chart is likely to be photocopied then you need to ensure that the critical information will be preserved in the copy.
  - Vertically-orientated text should be avoided if possible (especially for situations where words are written vertically but printed with horizontally-orientated letters).

Upper case labels should be used sparingly (they attract attention but are slower to read). Compressed fonts (e.g. Arial Narrow), switching font types, and serif fonts (serifs slow reading of short pieces of text) should be avoided.

- Data entry layouts should support both left and right handed clinicians.
- The chart should be legible enough so that even a fatigued clinician can still use it with minimal errors.

6. Have you considered ways to reduce common errors such as row and column shifts?

In the ADDS chart, we endeavour to reduce row shift errors (users accidentally jumping into the wrong row when reading across a table) by labelling all vital sign graphs to both the left and right of the graph area. This also served to help left-handed users, who might cover any scale along the right-hand side of a graph with their writing hand when entering data. To minimize column shift errors (users accidentally skipping into the wrong column when reading down a chart) we placed bold lines between every three columns. The same approach can be used to minimize row shift errors in situations where there are a large numbers of rows with the same background colours.

- Have you identified the most common sources of errors that occur in pre-existing versions of the chart you are developing? Can you minimize these errors through design?
    - For example, if your chart requires the same data to be entered in more than one location then this could potentially increase the chance of errors being made.

7. How easy is the basic functionality of the chart to understand?

The easier a chart is to use and understand (without the need to refer to additional reference material) the better. We designed the ADDS chart so that only a minimum of additional explanation was required by users. This issue would affect elements such as the amount of explanatory information provided on the chart itself. It is critical to design your chart to take into account the training, skills, competence, motivation, and workplace culture of those who will use it.

- How quickly can both novice and experienced users learn to use your new chart?
    - Can a non-clinician follow the instructions to enter the data and interpret the chart without a complex training program? If even a non-clinician can perform the relevant tasks with minimal training then it is likely that novice clinicians will also be able to use your chart safely.
    - Can experienced clinicians use your new chart without confusing it with existing charts?

8. Is the language and labelling on your chart as clear and understandable as possible?

We found substantial variation in the labels used for vital signs across different charts. For example, we found 18 different abbreviations for oxygen saturation across 25 charts. We also found the same acronym could refer to different concepts in different charts. Some of the charts we reviewed also contained spelling and grammatical errors which potentially could lead to a lack of clarity.

- Does your chart use standardised notation? The following are examples of some critical considerations.
    - Are your labels likely to be immediately understood by all users, regardless of their training and background?
    - Are your labels descriptive enough that clinicians from all disciplines can understand them? For the ADDS chart, we surveyed health professionals to determine the preferred terminology to use in our chart and, where possible, we used the full name rather than an acronym to minimize the amount of pre-existing knowledge required to interpret the chart.
    - Is all the written material on the chart as clearly worded as possible?

9. Is the data on your chart presented in the most appropriate format?

For the detection of patient deterioration, presenting vital sign data as graphs was considered far superior to presenting the data numerically. This is because trends can be seen much more easily. Many existing charts used graphs in which there were multiple vital signs plotted in the same graph area, which was considered problematic because of the visual clutter generated (potentially making deterioration harder to detect). In our chart, each vital sign was plotted on a separate graph to avoid this problem (minimizing the chances of a user confusing two data points for different vital signs). Some charts had data points orientated on different axis (vertical versus horizontal) which was considered to be particularly confusing for the user.

- Does the design of your graphs support the appropriate level of prominence and proximity for information displayed? The following are examples of some important considerations.
    - The areas of the graphs and associated scales must be large enough for trends to be seen easily.
    - The labels on your graphs should specify the unit of measurement and give an example of how to plot data.
    - Axis scales should be consistent across their full range. On some of the charts we reviewed, the spacing of scales changed across the range of the scale (for example, scale points 1 to 10 might be displayed over the same physical distance on the graph as scale points 11 to 50), which could give a misleading impression of trends.
    - The value labels on the graphs should be appropriately and unambiguously aligned with the data. In some of the existing charts we reviewed, there was some ambiguity

(e.g. values were sometimes places next to graph lines and sometimes placed in the space between lines).

10. Are the different elements of your chart appropriately separated?

Information that is visually grouped is much easier to interpret. Formatting (e.g. separation by bold lines or spaces) can be used to separate adjacent but unrelated information. Critical information on some of the charts we reviewed was sometimes hidden amongst low value information. Also low value information was often allocated a disproportionate amount of space (see also point 2).

- Can even novice users see the grouping of information on your chart clearly?
    - For example, the ADDS chart used bold horizontal lines to separate the graphs for the different vital signs (spaces were also considered as separators but this would have left too little space to fit all the vital signs onto one page).

11. Has your chart made full use of alerting systems to aid user decisions?

Around a third of the charts we surveyed included "track and trigger" systems, designed to alert users to deteriorating patients. We used two track and trigger systems in the ADDS chart. The first was a single parameter system, where users were instructed to activate an emergency team response if data for one or more vital signs was recorded onto a purple-shaded area of the chart. The second was a multiple parameter system, involving coloured bands on the vital sign graphs that corresponded to different levels of deterioration. If a vital sign reading was plotted onto a coloured area, this signalled that the vital sign was outside of the normal physiological range. The colour itself indicated the degree of the problem and could be scored (where scores across all vital signs were summed to create an overall score that summarized a patient's physiological state). This number corresponded to an action plan, which was detailed on the same side of the chart as the data. The first system (single parameter) was considered easier to use but potentially less sensitive to deterioration whereas the second system (multiple parameter) involved more work for the user but had the potential to be more sensitive to detecting patient deterioration, while minimizing false alerts (and provided a summary of a patient's overall physiological state). Even though the multiple parameter system on the ADDS chart makes it appear more complicated than single parameter systems, the data from the evaluation studies indicates that the ADDS chart is more accurate and faster to interpret than single parameter charts. This is likely to be due to the more effective layout of information. Importantly, learning to use the ADDS chart does not require substantial training. For example, the self-teach instructional package we developed to train novices and professional clinicians how to fill out and interpret the two versions of the ADDS chart (including how to use the multiple parameter system) in our evaluation studies consisted of participants watching a seven minute video and then engaging in a brief practice exercise.

- If your chart includes alerting systems, are they as easy to understand and use as possible? The following are examples of some of the critical issues.

- Well designed charts should require minimal training in order to use.
- Any opportunities for users to misinterpret the information on your chart should be mitigated.
- Any action plans on the chart should be clearly worded and appropriately descriptive, without requiring users to refer to other sources of information.
- Your system should be simple enough so that even a fatigued clinician can still use it with minimal errors.

12. Does your chart make appropriate use of colour?

Colour is a powerful tool to improve the usability of charts. In our chart, we used colour as part of the track and trigger systems (see point 11).

- Does colour support the appropriate level of prominence of information on the chart?
    - Avoid using too many colours on the chart.
    - Consider the effect of colour on legibility (see point 5 above).
    - Use an intuitive choice of colours where possible (for example, more intense colours would be expected to indicate a more severe problem).
    - Due to the proportion of colour-blind individuals in the population, colour choice should also be discernible by brightness as well as hue. For the ADDS chart, we selected and tested colours to minimize problems for colour-blind users.

13. Is your chart the most appropriate size and orientation for the task?

We decided that a landscape-orientated A3 sized chart (rather than an A4 sized or portrait-orientated chart) was most appropriate for our purpose, as it allowed all the related information to be displayed on a single side, without the user having to turn the page to look up or compare information.

- Are there any practical issues that might affect the useability of your chart? Will any changes to the work environment be required (for example, can your chart be used with standard clipboards if applicable)?
    - For example, we considered it important to have all eight vital signs legible on the ADDS chart plotted on the same page. The use of landscape orientation increases the area that a user can attend to because of the “letter-box” shape of the human visual field. Note that the choice of A3 was a compromise: an A4 sheet is likely to be more convenient to handle and file than A3, but this was considered less important than the opportunity to decrease errors affecting patient safety. However we did

ensure that the spaces on the form where data were to be recorded were on the left hand side of the page. This meant that the form could be used with a standard A4 clipboard: the chart could be fastened onto the clipboard by its left hand side and then folded out for use (where the right hand side of the page, which was not positioned against a writable surface, contained mainly reference material).

14. What evidence do you have that your chart is safe?

Never fall in love with your own chart design; rely on what the evidence tells you! It is absolutely critical to collect scientific evidence to determine whether your chart is well-designed. If the evidence does not support your design then you must be prepared to change it. Without evidence, your chart design is based on nothing but opinion and even expert opinion has frequently been found to be wrong. You should treat your own paper chart in the same manner you would a new drug or some new patient monitoring equipment. You need to understand the limitations of your chart and the risks you have taken in your design (given that all paper-based charts will require compromises). Evidence from the ADDS chart evaluations demonstrates that chart layout can reduce interpretation errors by 60 to 70 percent. One interesting finding from the ADDS project is that error rates resulting from data interpretation were considerably higher (over 35% in some circumstances) than errors in recording data (under 2%, even under poor working conditions). This suggests that future chart evaluation studies should focus on measuring data interpretation error rates rather than data recording error rates.

- Is the design of your chart supported by evidence from behavioural research studies involving both novice and experienced participants?
    - Your evaluation team should contain a human factors specialist.
    - You should conduct a data interpretation study to measure the error rates and speed of decision-making for individuals using your chart (read the reports from the ADDS chart project, available from the Commission website, to see an example of how it ought to be conducted).
    - You should also conduct a clinical trial and an audit of errors made by those using the chart.
    - You should establish an effective training program for individuals using the chart in order to minimize the risks of incorrect chart usage. However do not rely on training to reduce errors that are caused by poor design.

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