hscic Health & Social Care Information Centre

Displaying Graphs and Tables

User Interface Design Guidance

Prepared for

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PREFACE

Documents replaced by this document

Document Title	Version
Displaying Graphs and Tables – User Interface Design Guidance	1.0.0.0

Documents to be read in conjunction with this document

Document Title	Version
Design Guide Entry – Date Display	3.0.0.0
Design Guide Entry – Time Display	3.0.0.0

This document was prepared for NHS Connecting for Health which ceased to exist on 31 March 2013. It may contain references to organisations, projects and other initiatives which also no longer exist. If you have any questions relating to any such references, or to any other aspect of the content, please contact cuistakeholder.mailbox@hscic.gov.uk

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1 INTRODUCTION

Table 1 describes the changes made since the previous version of this document:

Previous Baseline Version	Previous Baseline Date	Changes Since Previous Baseline
1.0.0.0	15-Sep-2008	The following table summarises updates that have been made to this document: **Modified**: ▪ GTAB-188 and GTAB-189 have been reworded to further mitigate safety issues

Table 1: Changes Since the Last Baseline Version

1.1 Customer Need

Clinical data represented numerically, such as physiological observations or 'vital signs' readings, play a crucial role in clinical decision-making and in communicating with patients, which in turn can influence patient involvement with their treatment regimen. In addition to accurately reading such numerical data, clinicians must also interpret patterns in the data to assess the patient's status and to determine the best course of action. This often requires them to rapidly assimilate multiple series of data. Often, these patterns are difficult to spot initially, but become more distinct as a pathology develops and it is imperative that clinicians can detect them as early as possible. Pattern detection is a universal human capacity which people tend to do very efficiently and often subconsciously. However, the detection and meaning of a data pattern can be heavily influenced by the way in which the data is presented, and misinterpretation may occur if the data is not presented in a way that clinicians can easily understand.

In a clinical context, this may mean that important patterns could be missed or are detected too late. Although, in acute care, early warning scores are effective for detecting problems, in other clinical contexts, and for subtle data patterns, measurements may need to be displayed graphically for changes to be perceived.

Also, in order that patients can comply with the care intervention, such as changing their lifestyle or taking medication, it is crucial that they can understand their condition, their likely prognosis and the physiological targets they must achieve in order to get better. Health psychology research has shown that patients' understanding of their condition and likely outcomes are often subject to bias. Whereas people often find it hard to see trends and deficits in numerical data, graphical representations effectively communicate the pattern and direction of physiological signs, along with the changes that patients' must effect to reach their targets. With this understanding, patients' get feedback on their behaviour in order to better regulate it.

This guidance aims to define the key factors that influence the interpretation of patterns in clinical data, focusing upon scatter and line graphs and tables.

This guidance draws upon User Interface (UI) current best practice and upon research into the use of graphs and tables in clinical settings.

This guidance is for use by Independent Software Vendors to ensure that good design principles support clinicians' interpretation of numerical data, reveal critical patterns and assist users in accessing specific data values.

1.2 Potential Patient Safety Risks to be Mitigated

The development of this guidance relied on identifying a set of high level tasks associated with the use of clinical charts (that is, graphs and tables).

We identified risks associated with those tasks by running risk assessment activities, interviewing clinicians in early design analysis and requirements capture exercises (including **{R5}**) and consulting a number of sources, including existing studies[1] and papers (**{R11, R15}**).

These tasks were located in a set of typical user scenarios and a set of potential patient safety risks and consequences were noted with these scenarios. A full outline of these tasks, scenarios, and potential safety risks can be found in APPENDIX A.

The high level tasks comprise:

- Read the current data values
- Compare the current data values with past readings
- Check if the current data values exceed, fail to exceed or fall below a threshold
- Check for significant patterns over time in a series of data values
- Check for significant interactions between data series
- Check the provenance of the data values
- Check if there is a significant change in values from their normal levels

The main potential patient safety risks identified in the context of clinicians interpreting chart information include:

- Overestimation of a trend, either a rise or fall
- Not viewing a relevant previous set of data or not recognising when it was taken
- Not identifying a drop in blood pressure as being significant:
  - Not seeing how much it has dropped
  - Not seeing how quickly it has dropped
- Not seeing a drop in blood pressure in the context of the oxygen, pulse and temperature remaining constant
- Not seeing that the respiratory rate has increased slightly
- Not correctly reading the absolute values of a measure
- Not factoring in that the differences in readings may be partially or wholly accounted for by the change in settings in which the readings were taken
- Not seeing the current configuration of the vital signs (for example, high, low, rising)
- Not recognising that the data is now showing a new trend
- Not recognising a previous trend
- Not recognising the differences between the two trends
- Not recognising that the change in trend is significant
- Not recognising where the patient's current blood pressure readings are in relation to the target range

[1] Acutely ill patients in hospital: Recognition of and response to acute illness in adults in hospital **{R1}**: http://www.nice.org.uk/CG50

- Not accurately reading the patient's current blood pressure reading
- Not being able to view the current configuration of the observations data in relation to the patient's usual levels
- Not identifying the rise in blood pressure and pulse as significant:
  - Not seeing by how much they had risen
  - Not seeing how quickly they had risen
- Not identifying the drop in a measure as significant:
  - Not seeing by how much they had dropped
  - Not seeing how quickly they had dropped
- Not being able to view the changes in blood pressure and oxygen saturations in relation to each other
- Not recognising that the blood pressure has stabilised
- Not recognising that the patient's blood pressure readings are in the target range

The consequences for such risks could be:

- A delayed diagnosis
- A delayed treatment
- An incorrect diagnosis
- A missed diagnosis
- An incorrect treatment
- Failure to comply with treatment regimen

The design guidance points outlined in later sections aim to mitigate these patient risks.

1.3 Scope

The main purpose of this guidance is to allow electronic clinical systems to clearly and effectively communicate levels and patterns of data to the clinician and patient.

In order to provide further focus to this guidance, it is primarily restricted to the key physiological observations that serve as fundamental indicators of patient health, otherwise known as 'vital signs' data. Specifically, the guidance addresses these forms of data:

- Blood pressure, comprising systolic and diastolic pressures, measured in millimetres of mercury (mmHg)
- Body temperature, measured in degrees centigrade (˚C)
- Pulse rate, measured in beats per minute
- Respiratory rate, measured in breaths per minute
- Oxygen saturation, expressed as a percentage (%)

These are commonly used, individually or in combination with themselves or other measurements, throughout the healthcare industry. The regular recording of these measurements is also mandated by the recent National Institute for Health and Clinical Excellence (NICE) guidelines for acute care

{R1}. Those guidelines serve as exemplars for this guidance. It is expected that guidance applying to those measurements can also be generalised to other data types, although care must be taken by suppliers when doing so. In some cases, additional design considerations may apply that are out of scope for the current guidance. Parts of this guidance expand this set of exemplars to include some blood test results, such as serum creatinine and serum urea levels, but generally the focus is upon the five 'vital signs' data listed above.

Patterns of change through time are formed primarily by combinations of four characteristics (taken from Stephen Few **{R8}**):

- Magnitude of change
- Shape of change
- Velocity of change
- Direction of change

Positioning graphical representations of data in a two dimensional plot area is an effective, efficient and well-recognised way of communicating these factors. Time-based scatter plots with interpolated data points are currently used throughout the healthcare industry, often in paper form. Although more innovative, but unconventional, data visualisations are available, this guidance focuses upon the design of interpolated scatter plots because their understanding is immediate and relatively little learning is required by the clinician to interpret them.

The purpose of the guidance is therefore to ensure that this conventional graphing method is as clear, efficient and safe as possible when presented electronically, rather than trying to push the boundaries of data visualisation techniques. Additionally, there will be occasions where the clinician will also want to view the data solely as numerical data; if, for example, they are more concerned with the absolute values rather than the patterns they form.

To achieve these goals, this guidance will identify the basic components of both conventional graphs and tables and will address these in turn. The primary focus is upon the static views of graphs and tables whilst acknowledging that the interaction between the clinician and the data also has an impact on the interpretation of data and needs careful handling. The emphasis is upon format rather than specific content, although with indication where certain types of content will be required.

> **Note**
>
> Definitions for terms which have a specific meaning in the context of this document are listed in section 11.2.

1.3.1 Data Values and Labels

In Scope	Out of Scope
Creating symbols for data glyphs in graphs	This guidance does not specify symbols for specific data types, with the exception of blood pressure. Instead, it outlines the rules that a designer must follow when creating a set of data symbols
Identifying data series	This guidance does not specify the exact wording of the data series (for example, we will not mandate 'Heart rate' over 'Pulse rate'). However, it recommends that suppliers use standard terms where possible (for example, from the Systematised Nomenclature of Medicine-Clinical Terms (SNOMED-CT)
Displaying data units	This guidance does not specify a comprehensive list of units This guidance does not cover translating values from one unit to another
Displaying two data values that are linked together	This guidance does not cover any value linkages that are not blood pressure

In Scope	Out of Scope
Displaying paired values, such as systolic and diastolic pressure. Also, displaying pairs of paired values, such as lying and standing blood pressures (which are themselves pairs)	This guidance does not cover paired values that are not blood pressures
Displaying numerical value labels in graphs	This guidance does not specify exact positions of labels. Also, the precision of data values will not apply to any data variable other than the vital signs data series
Displaying numerical values in tables	
Allowing access to numerical (digital) value labels in graphs	This guidance does not specify in precise detail the mechanism used to access views to numerical values. For example, although it may recommend a hover-over or a toggle switch, it is not going to detail the precise UI interaction required for a hover-over, nor the exact formatting or position of the toggle switch
Distinguishing manually input data values from values feeding in directly from a machine. **Note** Manually input readings include those that have been read from a machine, but manually entered	This guidance does not provide any special guidance for continuous data input. Its focus is on readings that have been made (and entered) by a clinician. Where readings come directly from a medical device, it recommends that these are distinct from manually input readings
Allowing the user to focus on specific data values **Note** This will include separate guidance for graphs and for tables	This guidance does not specify exact mechanisms for focusing upon data values, nor hotspot dimensions or rules nor the precise user interaction required for selecting a value (for example, the precise look of a fish-eye or a crosshair)
Special guidance when overlaying graphs	
Displaying data overviews or summaries	This guidance does not specify the exact form, formatting or interaction of look-head scrolling nor thumbnails. This guidance does not specify an exhaustive list of summary data that could be displayed
Allowing the user to switch between graphs and tables	This guidance does not specify the exact mechanisms for switching between graphs and tables This guidance does not cover the display of mean, peak and low values: ■ When to display peaks and lows ■ Labelling of peaks and lows ■ For what range to display peaks and lows ■ Where to display peaks and lows data

Table 2: Data Values and Labels Scope

1.3.2 Scaling

In Scope	Out of Scope
Optimum scaling	This guidance does not cover any data that is not featured in the list of observations data (that is, the vital signs) The guidance may not be able to define precisely an optimum scaling; instead it outlines what factors to consider when setting the scaling and ways to ensure that scaling is kept consistent within any given system
Minimum scales	This guidance does not specify absolute minimum scales (that is, the shallowest that the y-axis can be in relation to the x-axis)

In Scope	Out of Scope
Dynamic scaling	This guidance does not cover any data that is not in the list of vital signs This guidance does not define any mechanism for changing the scaling (for example, a zoom control or a scale slider).
Dealing with extreme values	

Table 3: Scaling Scope

1.3.3 Axes

In Scope	Out of Scope
X-axis and y-axis arrangements	This guidance does not recommend default views, but will not go as far as recommending that no other data except for time should appear on the x-axis
Time axis intervals	This guidance does not define a mechanism for setting or changing time intervals or scales
Data variable (non-time) axis intervals	This guidance does not cover logarithmic data representations
Data variable (non-time) ranges	
Gridlines	This guidance does not define a mechanism for revealing/hiding gridlines
Axes labels	
Special axis considerations in the event of overlaying graphs	This guidance does not define the workings of any interactive mechanisms for viewing overlaid graphs

Table 4: Axes Scope

1.3.4 Layout Density and Formatting

In Scope	Out of Scope
Typefaces	
Background colours	
Foreground colours	
Labelling of graphs and tables	This guidance will only be defining label design, not content
	This guidance does not define the optimum or minimum width and height of the graphing area **Note** This may need to be defined in the context of an assumed screen resolution or as a function of screen resolution

Table 5: Layout Density and Formatting Scope

1.3.5 Simultaneous Views of Multiple Data Series

In Scope	Out of Scope
Considerations for viewing multiple, non-overlaid graphs	This guidance does not cover mechanisms for adding or removing data series from view. It will not define mechanisms for changing the order of multiple graphs
Considerations for viewing multiple, overlaid graphs	This guidance does not define mechanisms for overlaying or semi-overlaying data series

Table 6: Simultaneous Views of Multiple Data Series Scope

1.3.6 Interpolation

In Scope	Out of Scope
When to show interpolation	This guidance does not specify what to do when interpolation has to cease for a data series (for example, when data is unknown for a given period)
Formatting of interpolation	This guidance does not define any algorithms for smoothing interpolation lines
Special formatting in the event of overlaying or semi-overlaying data series	

Table 7: Interpolation Scope

1.3.7 Indicative Ranges

In Scope	Out of Scope
Normal ranges	This guidance does not define mechanisms for adjusting normal ranges nor for switching normal ranges on or off This guidance does not specify the label text for normal ranges.
	This guidance does not specify target ranges and critical thresholds: ▪ When to show target ranges, critical ranges or thresholds ▪ Formatting of target ranges, critical ranges or thresholds ▪ Formatting of target ranges, critical ranges or thresholds ▪ Labelling target ranges, critical ranges or thresholds ▪ Changing target ranges, critical ranges or thresholds It does not define mechanisms for changing target ranges, critical ranges or thresholds, nor does it specify the label text for target ranges, critical ranges or thresholds.

Table 8: Indicative Ranges Scope

1.3.8 Tables

In Scope	Out of Scope
Table orientation and scaling	This guidance does not define mechanisms for switching the orientation of tables nor the direction of data It does not address viewing table data and graph data simultaneously
Table formatting	This guidance does not define mechanisms for scrolling, sorting and filtering

Table 9: Tables Scope

1.3.9 Additional Contextual Information

In Scope	Out of Scope
Displaying contextual data	This guidance does not list all contextual information to be displayed
Accessing contextual data	This guidance does not define the precise mechanisms for accessing contextual data that is not immediately visible

Table 10: Additional Contextual Information Scope

1.3.10 Additional Visualisation Mechanisms

There are many potential data visualisation mechanisms that could be employed to assist the interpretation of clinical observations data, such as zoom views, event timeline overlays and further statistical analysis and calculation methods, such as mean and peak values and trend lines.

However, these are out of scope for the current work. Consideration was given to a mechanism for calculating deviations between a baseline value set by the clinician and more recent values, but this was not deemed essential by the clinical audience who reviewed the scope of this guidance.

1.4 Assumptions

ID	Assumption
A1	Absolute space (that is, the dimensions of the screen available for displaying a graph or table) will vary between suppliers.
A2	Although this guidance focuses upon vital signs data, where they deem it appropriate, suppliers should apply this guidance to other data series
A3	The interpretation of graphs and tables should be done in the context of early warning scoring systems where applicable (for example, Modified Early Warning Score (MEWS) or Patient At-Risk Scores (PARS))
A4	Where necessary, indicative or 'normal' ranges for a given population should be agreed by the supplier with the appropriate professional bodies or appropriate clinical authority.
A5	Measurement labels should be expressed in SNOMED-CT terms
A6	Clinicians may view graphs and tables on a variety of hardware platforms. However, special provision for non-PC platforms is not covered by the current guidance

Table 11: Assumptions

1.5 Dependencies

ID	Dependency
D1	There exists an accompanying mechanism for entering the observations data (not in scope in the current document)
D2	The display of dates must conform to the guidance for Date Display **{R3}**
D3	The display of times must conform to the guidance for Time Display **{R4}**

Table 12: Dependencies

1.6 Summary of Guidance

Table 13 references and provides a brief description of each guideline in this document.

> **Important**
>
> The information in Table 13 is provided only as a high-level orientation aid and indicative summary. To obtain the definitive statement of each guideline, you must refer to the sections and examples indicated.

Reference	Section	Description
GTAB-001	2.1	Display the time-based observation data as points rather than bar charts or area graphs (Example 1)
GTAB-002	2.1	Each data series should be represented by a different symbol and colour combination (Example 1)
GTAB-003	2.1	There should not be a fixed assignment of symbol-colour combination and data series beyond a viewing session, with the exception of the blood pressure composite.
GTAB-004	2.1	Symbols should be assigned to data points when the data series is added into a view
GTAB-005	2.1	After a data series has been brought into view for a given session, it must retain its symbol-colour combination until the end of the viewing session
GTAB-006	2.1	Each symbol should be distinct according to one or more factors (Example 2)
GTAB-007	2.1	Certain cues should not be used to distinguish a series of data points (Example 4)

Reference	Section	Description
GTAB-008	2.1	Where possible, avoid asymmetrical shapes or shapes that cannot be easily centred upon an x-y intersection (Example 8)
GTAB-009	2.1	Feature a set of colours that are sufficiently distinct to distinguish series of data points, such as red, green, yellow, blue, black, white, pink, cyan, gray, orange, brown, purple
GTAB-010	2.1	The height and width (or diameter) of a data point symbol icon must be larger than the width of the line of interpolation
GTAB-011	2.1	The height and width (or diameter) of a data point symbol icon must be kept to a minimum size, whilst not violating guideline GTAB-010
GTAB-012	2.1	The centre of the data point must be aligned with its corresponding x and y values
GTAB-013	2.1	Do not overlap symbols for data points (Example 11)
GTAB-014	2.1	When data points are arranged tightly on the x-axis, reduce the symbols to short, thick vertical lines in order to accommodate more within the space available (Example 9)
GTAB-015	2.1	When data points become so tightly arranged on the x axis, provide a (for example, hover-over) message that indicates the number of data points and a recommendation to view the data in greater detail
GTAB-016	2.1	Symbol sizes should remain unchanged, except when the data points are so close as to potentially overlap. Symbols should not increase in size upon zooming in or changing timescales
GTAB-017	2.1	Where a data value corresponds to a time that is less specific than the intervals shown in the selected time range, feature a different symbology (in addition to not interpolating the points)
GTAB-018	2.2	Every individual data series must be labelled (Example 13)
GTAB-019	2.2	Data series labels must be visible all the time that the values are displayed on-screen
GTAB-020	2.2	Where there is only a single data series in a graph space (that is, where there are no data overlays), the labelling should be positioned above the graph.
GTAB-021	2.2	Position the label either to the left of each graph or immediately above, and to the top left of, each graph (depending upon the space available) (Example 15, Example 16)
GTAB-022	2.2	Minimise the height of the labels positioned above the graphs in order to minimise the distance between graphs
GTAB-023	2.2	Visually associate the label with its corresponding graph by positioning it immediately adjacent to it (Example 17)
GTAB-024	2.2	Where there are multiple data series in a graph space (such as where one data series is overlaid or semi-overlaid upon another), the labelling should be positioned immediately next to or very close to the relevant data series (Example 19)
GTAB-025	2.2	Do not orient labels vertically (Example 18)
GTAB-026	2.2	Do not feature labels as watermarked text on the graph area (Example 20, Example 21)
GTAB-027	2.3	Data unit labels must be visible at all times that a data series is graphed (Example 22)
GTAB-028	2.3	Do not display values taken with different units of measurement in the same series of data values. In these cases, separate data value series are required (with separate axes) (Example 26)
GTAB-029	2.3	Do not display values taken with different units in the same sequence of data values in a table (either displayed in a column or in a row)
GTAB-030	2.3	If data values have been converted from one unit to another, the system must clearly communicate that this has happened at the level of the data value points
GTAB-031	2.3	Data unit labels may be expressed as abbreviations (such as ‘mmHg’)
GTAB-032	2.3	Where they are available, use standard abbreviations (such as ‘°C’)

Reference	Section	Description
GTAB-033	2.3	Abbreviations for data units should not be used where the abbreviations for two separate data units are the same
GTAB-034	2.3	The system should provide definitions of any abbreviated data units upon request (Example 27)
GTAB-035	2.3	The system could provide full data unit definitions as hover-overs (Example 27)
GTAB-036	2.3	Data units should be displayed alongside the data series labels (Example 23)
GTAB-037	2.3	Data unit labels can be displayed in a less prominent font size or weight than the data type labels (Example 23, Example 25)
GTAB-038	2.3	Data units do not need to be displayed next to each data value (Example 24)
GTAB-039	2.4	Systolic and diastolic blood pressures should be displayed on the same graph area (Example 28)
GTAB-040	2.4	Systolic and diastolic blood pressures should be displayed as opposite ends of a vertical line (Example 28)
GTAB-041	2.4	The intersection points (that is, the intersection between the x and y axes) for both systolic and diastolic pressures should be represented by a short horizontal bar, thus creating a double-ended 'T'
GTAB-042	2.4	The short horizontal bar which aligns with the y-axis values of the systolic and diastolic pressures should be a little thicker than any gridlines overlaid on the graph area
GTAB-043	2.4	Do not interpolate the blood pressure data points without the vertical lines connecting the systolic and diastolic pressure values
GTAB-044	2.4	When data points are positioned tightly together, the symbol becomes a straight vertical line between the systolic and diastolic values
GTAB-045	2.5	Display the most recent numerical value for each data series by default
GTAB-046	2.5	Display the penultimate numerical value for each data series by default (Example 33)
GTAB-047	2.5	Feature the most recent numerical value for each data series in a larger and/or heavier font (Example 33)
GTAB-048	2.5	Do not display all numerical values for a data series by default
GTAB-049	2.5	Allow the display of all the numerical values for a data series, upon request by the user (Example 34)
GTAB-050	2.5	Allow the display of any single numerical value, upon request by the user
GTAB-051	2.5	Display the numerical values adjacent to the graphical data points (Example 34)
GTAB-052	2.5	Display the numerical values in a consistent position in relation to the graphical data points (Example 34)
GTAB-053	2.5	Display the numerical values above or below the data points
GTAB-054	2.5	Display the numerical values to the precision in which they were recorded
GTAB-055	2.5	Feature the numerical values in a reasonably-sized font, namely based upon the prevailing good accessibility practice
GTAB-056	2.5	Feature the numerical values in a clear, undecorated typeface (Example 35)
GTAB-057	2.6	Provide a visual focus line that spans all data series and that is aligned to a chosen time. When the focus line crosses a value point, display the appropriate value label (Example 41)
GTAB-058	2.6	Allow some tolerance in the focus line, so that a data point will be picked up even if does not precisely align with the vertical line
GTAB-059	2.6	When the focus line crosses the value point, provide a background to the value label so that it is not obscured by the line
GTAB-060	2.6	For each data series, allow the user to reveal the value immediately preceding and the value immediately following the specific point in time, within a set tolerance

Reference	Section	Description
GTAB-061	2.6	Distinguish the values that are aligned with the focus line from the preceding and following values (Example 41)
GTAB-062	2.6	The visual focus can be moved between times or time ranges by the user (Example 42)
GTAB-063	2.6	The visual focus can be moved by moving the mouse over the top of the graph areas (Example 42)
GTAB-064	2.6	The visual focus can be moved by button presses and/or key presses: one for tabbing forward and one for tabbing back
GTAB-065	2.6	The visual focus line should be labelled with the time with which it is aligned (Example 41)
GTAB-066	3.1	There should be a linear relationship between data values and their spatial location (Example 43)
GTAB-067	3.1	In the default view of a graph, the time-axis should be scaled to one of a set of pre-defined time ranges
GTAB-068	3.1	Ensure that for each default timescale, there is a ratio of x-axis to y-axis ratio that is consistently applied
GTAB-069	3.1	The y-axis scale should be pre-determined by considering a number of factors
GTAB-070	3.1	Where a normal range is to be shown on the graph area, the default graph view must be sufficiently high to show the normal range plus a margin
GTAB-071	3.1	Ensure that, in the default view, the clinically significant changes (rises or falls) are always detectable by the clinician.
GTAB-072	3.1	In the default view, do not optimise the view by maximising the size of the data to fill the graph area
GTAB-073	3.1	Allow the user to choose to optimise the view (that is, maximising the data to fill the graph area)
GTAB-074	3.1	If re-scaling is required, minimise the number of scale gradations and/or the number of re-scaling steps
GTAB-075	3.1	Upon re-scaling from a default view scale, the system should display that the view is re-scaled
GTAB-076	3.1	In the event that, on a given scaling, the data requires more space than is available, re-display according to certain priorities
GTAB-077	3.1	If the scaling solution is based upon a shift up or down along an axis, provide a scroll feature when data falls outside of the visible axis range
GTAB-078	3.1	If the scaling solution is based upon a shift in axis, where data may fall outside of the visible range, provide a mechanism that communicates all the data within the given timeframe
GTAB-079	3.1	A thumbnail can be used to communicate all the data within a given timeframe if the main graph area does not show all the data simultaneously (Example 46)
GTAB-080	3.1	Where possible, show the data points on the thumbnail, although for large timescales containing much data this will not be possible and, in those cases, just show interpolation. (Example 46)
GTAB-081	3.1	Display the upper and lower axis ‘tick’ marks on the thumbnail (Example 46)
GTAB-082	3.1	Do not position the thumbnail in a position that obstructs the main graph (Example 46)
GTAB-083	3.1	Where appropriate, overlay an indicative range or line. Display this both on the main graph area and the thumbnail
GTAB-084	4.1	If time is displayed as one of the axes, it should be displayed along the (horizontal) x-axis (Example 48, Example 49)
GTAB-085	4.2	As a default, time must be displayed proportionally in observation graphs (Example 51)
GTAB-086	4.2	As a default, do not display data values non-proportionally along the time axis (Example 50)
GTAB-087	4.2	Mark the time intervals (that is, use hour marks, day marks, week marks and so on) (Example 52)
GTAB-088	4.2	Group the time intervals into higher units and distinguish these with more prominent markings (Example 52)

Reference	Section	Description
GTAB-089	4.2	Do not display tick marks for every possible time interval. Do not mark unconventional time intervals, such as every six minutes. (Example 53)
GTAB-090	4.2	Ensure that the time interval markings are always visible when graph data is being displayed.
GTAB-091	4.3	Feature markings for non-time variables along the (vertical) y-axis. (Example 54)
GTAB-092	4.3	Where possible, feature y-axis markings according to decimal intervals or intervals that are simple to add up (Example 55)
GTAB-093	4.3	When marking the y-axis, mark numbers for which it is easy to compute the mid-points (Example 57)
GTAB-094	4.3	Do not mark arbitrary intervals in an attempt to feature a fixed number of gradations (Example 56)
GTAB-095	4.3	Where appropriate, group the data intervals into higher units and distinguish these with more prominent markings
GTAB-096	4.4	By default, the x-axis should be constrained to one of a set of defined time ranges
GTAB-097	4.4	As new data points are added to a graph, do not change the time scaling. If adding the new data point means that the current data exceeds the time range, shift the time window to include the new data rather than increasing the time range in size. (Example 58)
GTAB-098	4.4	Do not show all data by default, unless there is a specific clinical reason for doing so
GTAB-099	4.4	If all data must be shown by default, the data should be shown within the nearest set timescale within which all the data to be displayed can be shown
GTAB-100	4.4	Y-axis ranges do not need to start from zero (Example 59)
GTAB-101	4.5	Feature horizontal gridlines for major gradations on the y-axis
GTAB-102	4.5	Ensure that, in the default view of data, horizontal gridlines are featured consistently for each data series
GTAB-103	4.5	Use gridlines sparingly. Do not feature gridlines for every possible gradation (Example 62)
GTAB-104	4.5	Feature vertical gridlines for major gradations on the x-axis (Example 60)
GTAB-105	4.5	Ensure that vertical gridlines are featured consistently for each time range window (Example 60)
GTAB-106	4.5	Use the same vertical gridlines for all graphs in view at the same time (Example 60)
GTAB-107	4.5	Offer users the option of (temporarily) switching off the gridlines
GTAB-108	4.6	Label the y-axis markings, not the spaces between them (Example 64, Example 65)
GTAB-109	4.6	Label the x-axis markings, not the spaces between them (Example 66)
GTAB-110	4.6	Avoid diagonally oriented label text unless additional grids are added to mitigate the risk of users associating a label with the wrong marking
GTAB-111	4.6	Avoid vertically oriented label text (for both the x-axis and the y-axis)
GTAB-112	4.6	On the x-axis, ensure that the full dates are always communicated
GTAB-113	4.6	If possible, communicate days of the week in the x-axis labelling (Example 68)
GTAB-114	4.6	Provide labelling of the time-range (Example 69)
GTAB-115	5.1	Display data points in high saturation colours except in those situations where the system needs to distinguish one data series over others (Example 70, Example 72)
GTAB-116	5.1	The colours of the data series should be approximately equal in terms of saturation except where one data series is being emphasised over the others
GTAB-117	5.1	Where one data series is required to stand out against the other data series, the others can be displayed in lower saturated versions of the same hues

Reference	Section	Description
GTAB-118	5.1	Where special low-light formatting is not required (that is, where the environment in which the data is to be viewed is well-lit, background colour for the graph area should be white or off-white
GTAB-119	5.1	The surrounding background for the graphs should be a neutral low-saturation colour (Example 72)
GTAB-120	5.1	Ensure a good contrast between the background colour and the foreground colours (Example 72)
GTAB-121	5.1	Provide a black border for data points. Reverse to a white border in the event of the colour of the data point being reversed (Example 73)
GTAB-122	5.1	Where special reverse formatting is required, ensure a good reverse contrast
GTAB-123	5.1	Use only a few colours if they are to be distinct. Using up to twelve colours is acceptable, but do not use more. Only use one of each colour category (Example 70)
GTAB-124	5.1	The first colours to be selected should be blue, red, and yellow, unless there is a background colour that conflicts with any of these colours
GTAB-125	5.2	Copy must be displayed in a sufficiently dark colour to contrast against the background
GTAB-126	5.2	Feature a font size of between 2 mm and 6 mm for the x-height of the letter (Example 74)
GTAB-127	5.2	Avoid visually elaborate typefaces (Example 75)
GTAB-128	5.2	Use a typeface or font family where the number 1 is clearly discernable from the lowercase letter 'l' or a capital letter 'J'
GTAB-129	5.2	Ensure that each kind of screen copy is displayed in a consistent typeface, size, colour and weight.
GTAB-130	5.2	Avoid underlines
GTAB-131	5.2	Avoid coloured text highlights
GTAB-132	5.2	Avoid animated or flashing text
GTAB-133	5.2	Do not feature text written vertically (Example 76)
GTAB-134	5.2	Avoid the use of brackets (either round or square) in the numerical value labels
GTAB-135	5.3	Format gridlines in a light grey colour (Example 77)
GTAB-136	5.3	Format gridlines in a light weight (Example 77)
GTAB-137	5.3	Make gridlines lighter in weight and colour saturation than the data points and the interpolation lines (Example 77)
GTAB-138	5.3	Format axis lines in a light grey colour (Example 77)
GTAB-139	5.3	Format axis lines in a light or medium weight (Example 77)
GTAB-140	5.3	Distinguish major axis marks from minor axis marks by weight and/or length
GTAB-141	5.4	Do not feature watermarks or background images on the graph area
GTAB-142	5.4	Feature solid colours and avoid patterned colours for both background and foreground objects (Example 79)
GTAB-143	5.4	Avoid any non-functional graphical elaboration that is not actual data or a feature that directly supports the interpretation of the data (Example 80)
GTAB-144	5.4	Do not force users to choose format styles each time they view the data
GTAB-145	6.1	Display multiple data series vertically stacked unless there is clinical reason to do otherwise (Example 81)
GTAB-146	6.1	Vertically align the left-hand axes of all the graphs (Example 81)
GTAB-147	6.1	Vertically align time intervals between data series that are being viewed simultaneously (Example 81, Example 82)

Reference	Section	Description
GTAB-148	6.1	Minimise the space between graphs, though allowing for the inclusion of header labels (Example 81)
GTAB-149	6.1	Where a convention exists, position sets of graphs in the appropriate order (Example 81)
GTAB-150	6.1	Where no convention exists, the position of graphs in the vertical stacking can be determined by the order in which they are added to the view
GTAB-151	6.1	The user should be able to change the order in which the graphs are stacked
GTAB-152	6.1	Where the number of graphs exceeds the vertical space available on screen, provide a suitable mechanism to move the viewing window up and down
GTAB-153	6.1	Where there are graphs that have been chosen for viewing, but are not in view, feature a suitable mechanism to communicate that there are further graphs not in view
GTAB-154	6.2	Graphs may be overlaid under certain circumstances (Example 83)
GTAB-155	6.3	If two data series displayed in the same graph area are measured in different units, show both axes (Example 85)
GTAB-156	6.3	If two axes are shown, label each axis (Example 85)
GTAB-157	6.3	If two data series displayed in the same graph area are measured in different units and the axes gradation spacing is different, do not show horizontal gridlines
GTAB-158	6.3	When multiple data series are displayed in the same graph area, label each data series in an appropriate place (Example 84)
GTAB-159	6.3	Avoid distinguishing multiple data series displayed in the same graph area with varying line styles
GTAB-160	6.3	When multiple data series are displayed in the same graph area, display the interpolation lines as semi-transparent (Example 84)
GTAB-161	6.3	Avoid relying on the distinction between green and red when displaying multiple data series
GTAB-162	6.3	Where multiple data series are displayed in the same graph area, feature hollowed symbols, rather than the usual solid symbols bound by a black border (Example 84)
GTAB-163	6.3	Where data points become tightly packed, reduce their size. However, do not reduce them to a height that is the same as or less than the width of the interpolation line (Example 86)
GTAB-164	7.1	By default, with certain exceptions, provide interpolation between data points (Example 87)
GTAB-165	7.1	Allows users to switch interpolation lines off
GTAB-166	7.1	Interpolation should comprise straight lines between data points. By default, do not ‘smooth’ interpolation lines (Example 88)
GTAB-167	7.2	Interpolation lines should be solid (Example 89)
GTAB-168	7.2	Interpolation lines should not obscure the data points (Example 90)
GTAB-169	7.2	Data value points should define the upper and lower points of the data sequence, not the interpolation lines
GTAB-170	7.2	Interpolation lines should be thinner than the data points they connect (Example 92, Example 93)
GTAB-171	7.2	Interpolation lines should be approximately half the height or diameter of the data points they connect
GTAB-172	7.2	Interpolation lines should be the same colour as the data points they connect (Example 91)
GTAB-173	7.2	Interpolation lines should feature some anti-aliasing
GTAB-174	8.1	Display normal ranges, but only where appropriate ranges exist (Example 94)
GTAB-175	8.1	Be consistent with how to display normal ranges: either shade the out-of-range areas or shade the in-range areas. Do not feature both styles in the same system (Example 95)

Reference	Section	Description
GTAB-176	8.1	Where appropriate, graphically display early warning scoring ranges, but only in conjunction with a mechanism that displays the numerical scoring as well
GTAB-177	8.1	Allow target ranges and critical thresholds to be displayed in addition to normal ranges
GTAB-178	8.1	Label indicative ranges with the population to which they refer (Example 94)
GTAB-179	8.1	Ensure that the indicative labels do not obstruct any data
GTAB-180	8.1	Where appropriate, normal ranges should be adjusted to suit the specific population
GTAB-181	8.1	Do not overlay multiple normal ranges on top of each other
GTAB-182	8.1	Feature normal ranges as areas rather than threshold lines
GTAB-183	8.1	Feature normal range overlays in low-saturation colours (Example 95)
GTAB-184	8.1	Normal range displays should not obscure any graph data
GTAB-185	8.1	Feature the systolic and diastolic normal ranges in different shades of colour (Example 95)
GTAB-186	9.1	Orient tables in a consistent manner, for a given data type and/or clinical setting or procedure
GTAB-187	9.1	Tables should follow a conventional orientation if one exists
GTAB-188	9.1	If a table is oriented with time ordered horizontally, by default the most recent data value must appear at the far right-hand side (that is, sorted from left-to-right) while ensuring that the most recent values are visible by default (Example 96)
GTAB-189	9.1	If a table is oriented with time ordered vertically, by default the most recent data value must appear at the top of the table (that is, sorted from bottom-to-top) while ensuring that the most recent values are visible by default (Example 97)
GTAB-190	9.1	Users must be able to re-sort data within the columns or rows
GTAB-191	9.1	Users must be able to re-orient the table (that is, transpose the rows to columns and vice versa)
GTAB-192	9.2	Feature light banding along the rows (Example 99)
GTAB-193	9.2	Do not feature heavy gridlines (Example 102)
GTAB-194	9.2	Round data displayed in table cells entries where it is not misleading to do so
GTAB-195	9.2	If numeric cell entries are rounded, the table must communicate that the data is rounded and the extent to which it is rounded
GTAB-196	9.2	If appropriate, allow users to read the full version of any rounded data
GTAB-197	9.2	Ensure that where there are multiple instance of the same date, or time within a date, the first instance is more visually prominent than the following instances (Example 103)
GTAB-198	9.2	Do not stretch tables to fill available space (this impedes horizontal scanning)
GTAB-199	9.2	Feature extra spacing every fifth row (this assists vertical scanning)
GTAB-200	9.2	Use a constant horizontal spacing for numerals (this ensures vertical alignment)
GTAB-201	9.2	Align the decimal marker for all numerals in a column
GTAB-202	9.2	If some numbers in a column do not feature a decimal place, but others do, do not add an unnecessary decimal place but instead provide padding within cells to allow for decimals (Example 100)
GTAB-203	9.3	Align column headings with their associated data (Example 104)
GTAB-204	9.3	If column headings are centred, they should be visually aligned over the column of data
GTAB-205	9.3	As far as possible, word row titles so they are of similar length

Reference	Section	Description
GTAB-206	9.3	Long row headings may be split into two or more lines, with the data aligning with the bottom line (Example 105)
GTAB-207	9.3	Avoid a heading that is significantly wider than the data it is indicating
GTAB-208	9.3	Keep column headings brief
GTAB-209	9.3	Clearly link column headings to their columns
GTAB-210	9.3	Top align column headings
GTAB-211	9.3	In wide tables, row headings may be provided at both ends of the row
GTAB-212	9.3	Allow sufficient space between columns to clearly separate them but no more (excessive space impedes horizontal scanning) (Example 104, Example 106)
GTAB-213	9.3	Do not display column headings vertically
GTAB-214	9.3	Column headings may be displayed at 45º to the column, if the heading is too long to display horizontally and cannot be wrapped adequately
GTAB-215	9.3	Provide special formatting if column headings are displayed at 45º so that it is clear which heading applies to which column (Example 107)
GTAB-216	9.3	Do not alternate between the directions of the 45º oriented text in the same table
GTAB-217	9.3	Always display both column and row headings
GTAB-218	9.3	Ensure that the column and row headings are always visible
GTAB-219	10.1	Provide contextual information about the way in which the reading was taken
GTAB-220	10.1	Make visible the contextual information about how the reading was taken by default
GTAB-221	10.1	Allow the user to interrogate the system to access further contextual information

Table 13: Summary of Guidance

2 DATA VALUES AND UNITS GUIDANCE DETAILS

Graphs and tables comprise a number of key components, the foremost of which are the data values and units. An example of a data value and its unit is '140 mmHg systolic pressure, taken at 10:30 17-Jun-2006'.

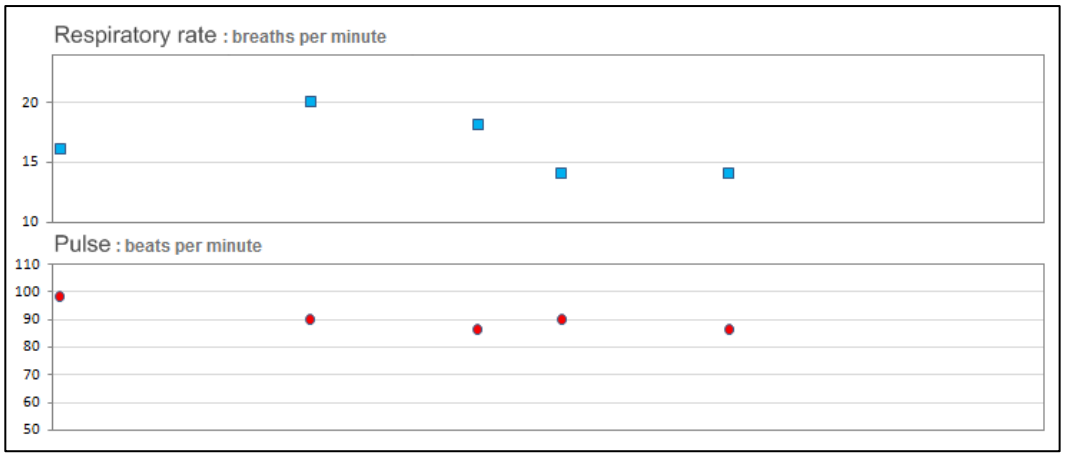
2.1 Guidelines – Creating Symbols for Data Points in Graphs

ID	Description	Conformance	Evidence Rating
GTAB-001	Display the time-based observation data as points rather than bar charts or area graphs (Example 1)	Mandatory	High
GTAB-002	Each data series should be represented by a different symbol and colour combination (Example 1)	Mandatory	High
GTAB-003	There should not be a fixed assignment of symbol-colour combination and data series beyond a viewing session, with the exception of the blood pressure composite. That is, when the clinician finishes the current patient consultation, the assignment of symbols and colours to a data series ends.	Mandatory	High
GTAB-004	Symbols should be assigned to data points when the data series is added into a view	Recommended	Low
GTAB-005	After a data series has been brought into view for a given session, it must retain its symbol-colour combination until the end of the viewing session	Mandatory	High
GTAB-006	Each symbol should be distinct according to one or more factors (Example 2): ▪ Shape ▪ Orientation ▪ Added marks ▪ Curved versus straight	Mandatory	High
GTAB-007	Certain cues should not be used to distinguish a series of data points (Example 4): ▪ Size ▪ Line width ▪ Line length	Mandatory	Medium
GTAB-008	Where possible, avoid asymmetrical shapes or shapes that cannot be easily centred upon an x-y intersection (Example 8)	Mandatory	Low
GTAB-009	Feature a set of colours that are sufficiently distinct to distinguish series of data points, such as red, green, yellow, blue, black, white, pink, cyan, gray, orange, brown, purple	Mandatory	Medium
GTAB-010	The height and width (or diameter) of a data point symbol icon must be larger than the width of the line of interpolation	Mandatory	Medium
GTAB-011	The height and width (or diameter) of a data point symbol icon must be kept to a minimum size, whilst not violating guideline GTAB-010	Recommended	Medium
GTAB-012	The centre of the data point must be aligned with its corresponding x and y values	Mandatory	High
GTAB-013	Do not overlap symbols for data points (Example 11)	Recommended	Medium
GTAB-014	When data points are arranged tightly on the x-axis, reduce the symbols to short, thick vertical lines in order to accommodate more within the space available (Example 9)	Recommended	Medium

GTAB-015	When data points become so tightly arranged on the x axis, provide a (for example, hover-over) message that indicates the number of data points and a recommendation to view the data in greater detail	Recommended	Medium
GTAB-016	Symbol sizes should remain unchanged, except when the data points are so close as to potentially overlap. Symbols should not increase in size upon zooming in or changing timescales	Recommended	Low
GTAB-017	Where a data value corresponds to a time that is less specific than the intervals shown in the selected time range, feature a different symbology (in addition to not interpolating the points) For example, if the data values correspond to whole days, and the time range spans two days with an axis marked in hours, use a different symbology	Recommended	Low

Usage Examples

Example 1: Display data points with distinct symbols (shown here without interpolation)



The above example shows data values being displayed as small symbols in a two dimension space. The top data series, shown in blue, is distinct in both colour and shape from the round red symbols below.

Example 2: Feature distinct symbols that vary according to shape and orientation

Example 3: Do not feature elaborate designs nor icons that have other meanings

Example 4: Do not distinguish symbols with size

Example 5: Do not distinguish symbols by width or height alone.

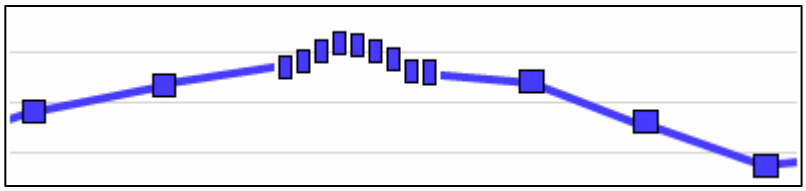
Example 6: Avoid distinction by orientation unless the re-orientation renders the symbols quite distinct

In this example the re-orientation does little to make the symbols distinct from each other

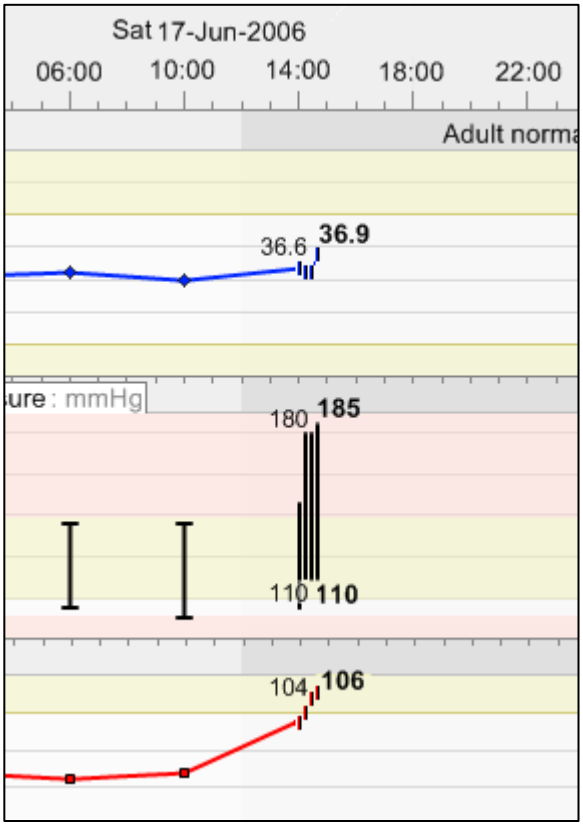
Example 7: Do not distinguish by multiplicity

Example 8: Do not feature very asymmetrical symbols which have no easily discernable mid-point

Example 9: Avoid symbol overlap by shrinking the icons to vertical bars when they become close

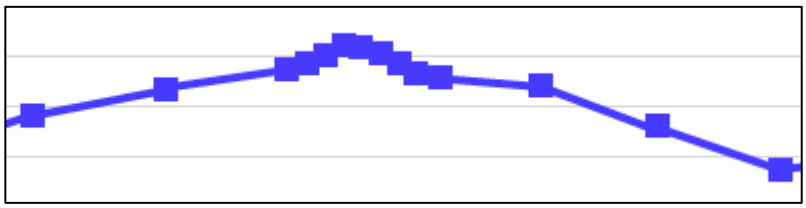


Example 10: Another example of avoiding symbol overlap by shrinking the icons to vertical bars when they become close



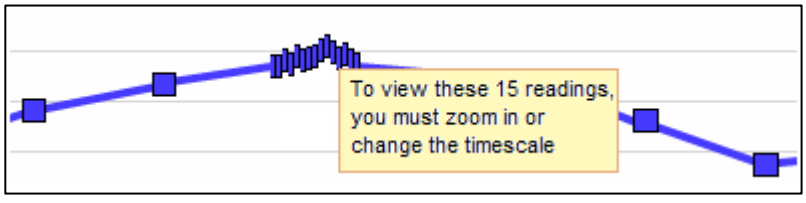
In the example above, the data symbols have had to shrink so that the readings taken every fifteen minutes can be seen on a 48-hour timescale that shows a range of four-hourly observations leading up the more intensive readings. This is close to the narrowest the symbols can be before they cannot be distinguished. If they reach a size where they cannot be distinguished, display a message to tell users that they must zoom in or change the timescale to view the individual points and their values.

Example 11: Where possible, avoid overlap



If overlap is unavoidable (that is, it still occurs after shrinking the icons), then feature a message on top to advise the user how many data points are contained in the bunching and a recommendation to zoom in or change the timescale to view the points distinctly.

Example 12: Force viewers to zoom or change timescale if the data is too tightly packed



Rationale

Displaying time-based observational data as points rather than bars or areas helps the user to see trends in the data. This notion is based upon best practice {**R8**} and existing clinical graphs. It is also much harder to overlay bar graphs or area graphs on top of each other so as to still distinguish between data series. Also, relevant British Standards state that the 'use of area graphs is not recommended' **{R2}**.

Data points that relate to the same data series should be:

- Perceived by the viewer as a single set
- Distinguished from other data series

This becomes more important when multiple data series are overlaid, as using the same symbology and colours could make it very difficult to distinguish one data set from another.

In the case of multiple, non-overlaid data series, the use of distinct symbol-colour combinations is important as it orientates the viewer as they:

- Move their attention between various on-screen elements
- Add new data series to a view
- Hide or reveal data series from immediate view

Distinct symbol-colour combinations also accentuate the grouping of individual data points within a series, thus helping the viewer to see them as a continuous series of measurements.

Symbols should be constructed with 'pre-attentive' cues, namely characteristics that require the minimum cognitive processing on the part of the viewer. Studies **{R19}** have revealed a set of visual cues that are pre-attentive. However, although considered pre-attentive, the following cues should not be used: size, length, width, multiplicity. This is because they also imply quantity.

Given the limited number of symbol-colour combinations in relation to a larger potential numbers of readings (when data is not restricted to vital signs), it would not be practical to feature a fixed assignment of symbol-colour combinations to data series.

The Common User Interface (CUI) research team user tested all of the recommended designs and found that they assisted users to understand the data.

People have a very strong tendency to perceive similarly coloured objects as belonging together **{R18}** as long as no more than three or four colours are used together.

The relevant British Standards Institution (BSI) guidance (BS 7581 **{R2}**) states that:

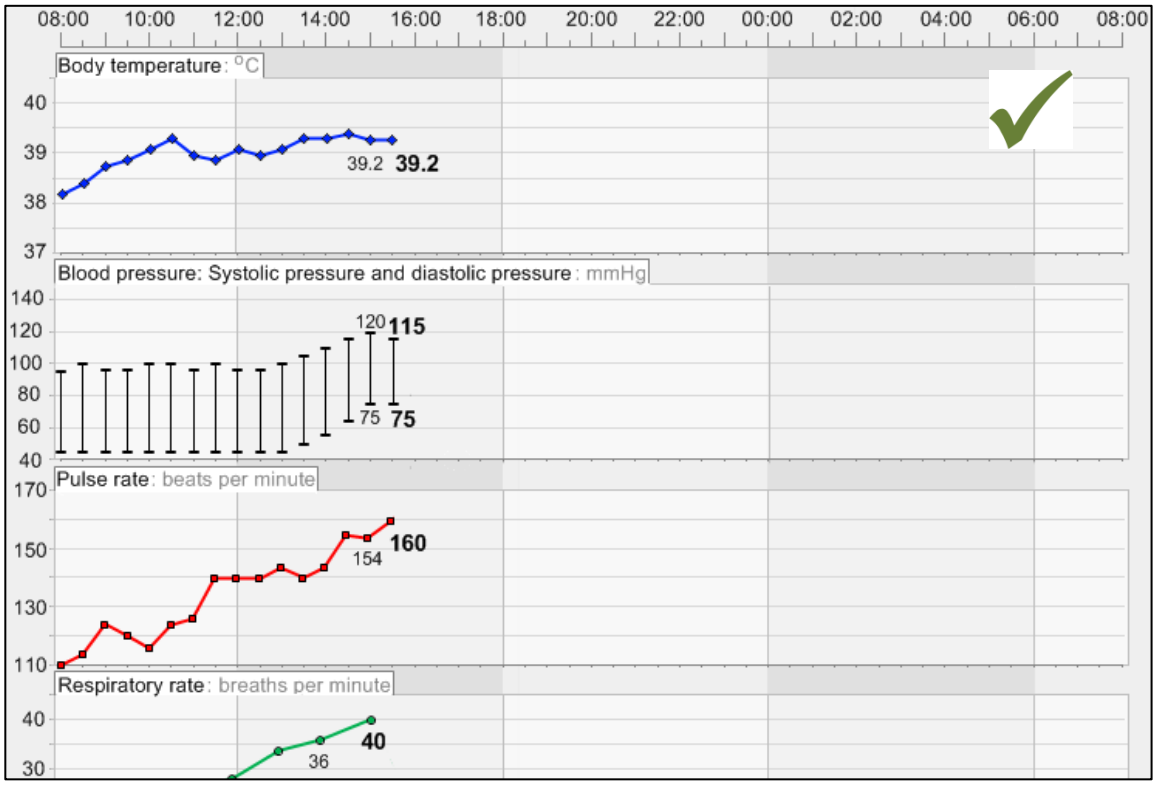
- 'Any coloured area should give sufficient contrast with the background'
- 'Any coloured area should be large enough for the eye to distinguish the colour'
- 'Not more than seven colours should be used in any scheme and not more than four if the reader is required to memorise their significance'

2.2 Guidelines – Identifying and Labelling Data

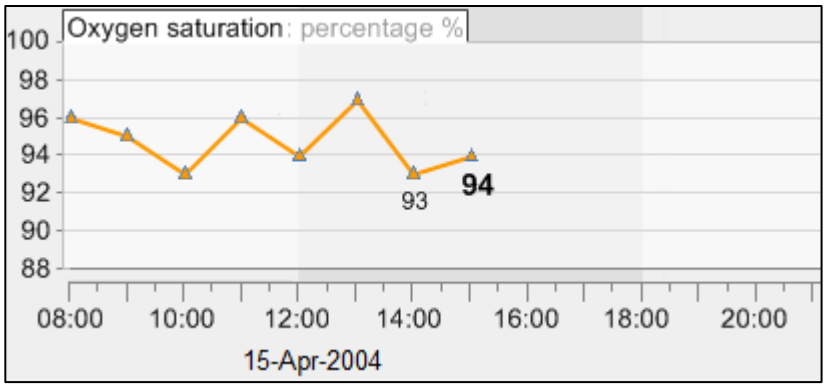
ID	Description	Conformance	Evidence Rating
GTAB-018	Every individual data series must be labelled (Example 13)	Mandatory	High
GTAB-019	Data series labels must be visible all the time that the values are displayed on-screen	Mandatory	High
GTAB-020	Where there is only a single data series in a graph space (that is, where there are no data overlays), the labelling should be positioned above the graph. Position the label where the data points (or the interpolation line) cannot touch or obscure it	Recommended	Medium
GTAB-021	Position the label either to the left of each graph or immediately above, and to the top left of, each graph (depending upon the space available) (Example 15, Example 16)	Recommended	Medium
GTAB-022	Minimise the height of the labels positioned above the graphs in order to minimise the distance between graphs	Recommended	High
GTAB-023	Visually associate the label with its corresponding graph by positioning it immediately adjacent to it (Example 17)	Recommended	Medium
GTAB-024	Where there are multiple data series in a graph space (such as where one data series is overlaid or semi-overlaid upon another), the labelling should be positioned immediately next to or very close to the relevant data series (Example 19)	Recommended	Medium
GTAB-025	Do not orient labels vertically (Example 18)	Mandatory	Medium
GTAB-026	Do not feature labels as watermarked text on the graph area (Example 20, Example 21)	Recommended	Low

Usage Examples

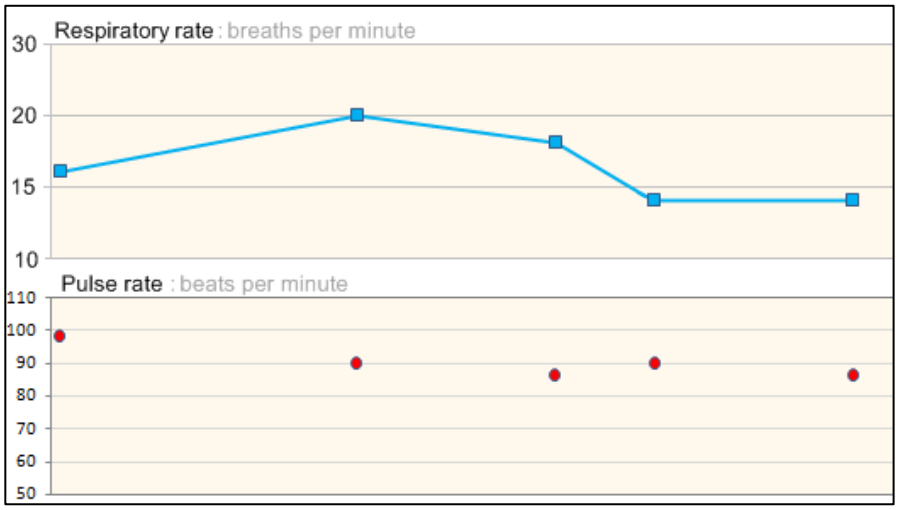
Example 13: Label each data series



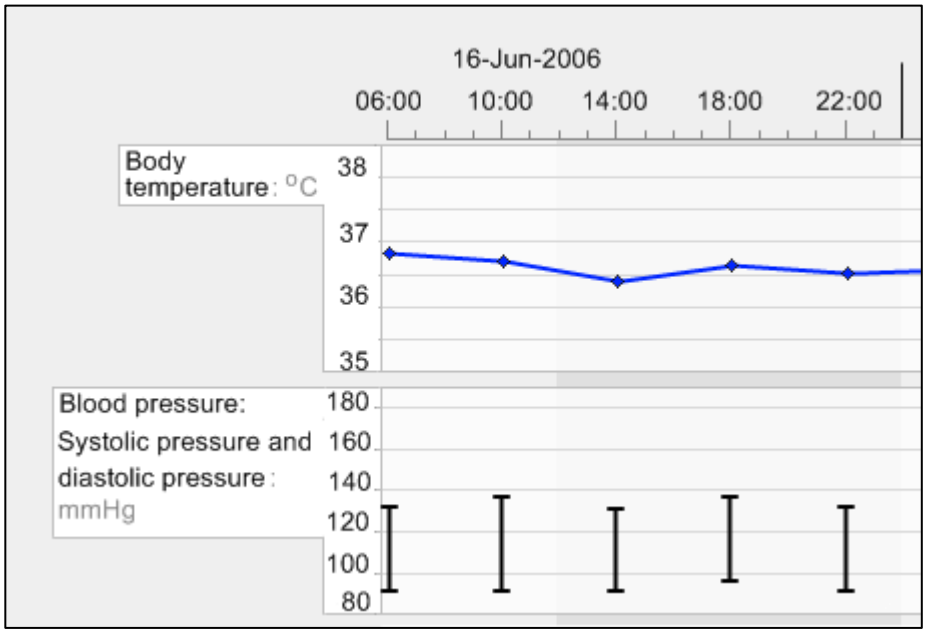
Example 14: Feature the label in the top left-hand corner for single data series graphs



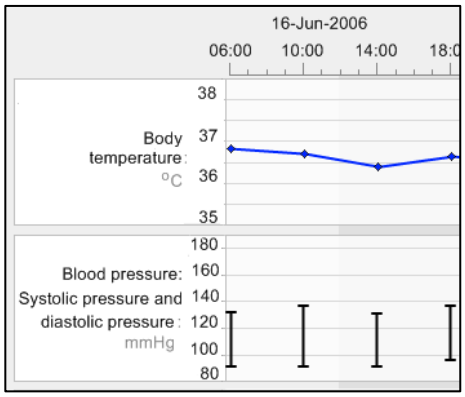
Example 15: Label at the top of the graph

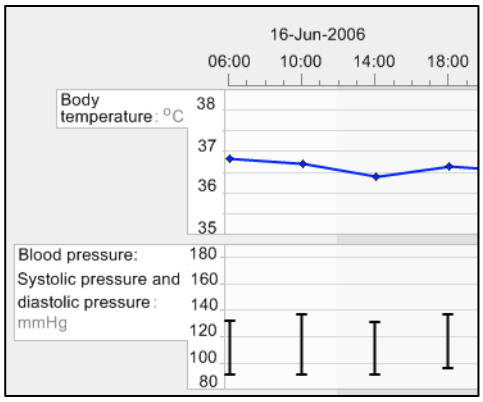


Example 16: Label at the side if there is sufficient space

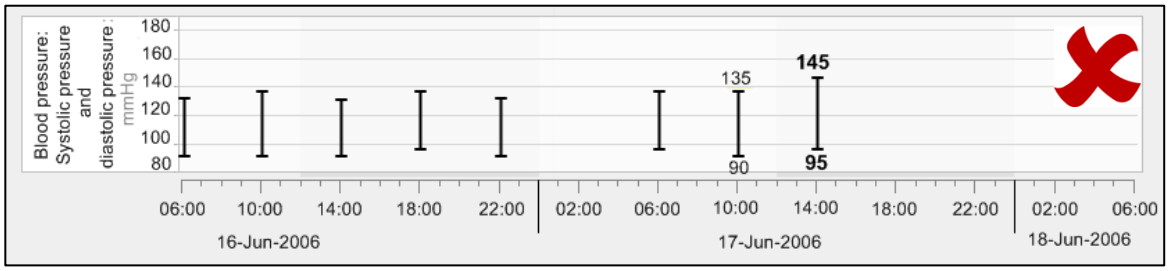


Example 17: Associate the label with its graph area through proximity, shading and borders

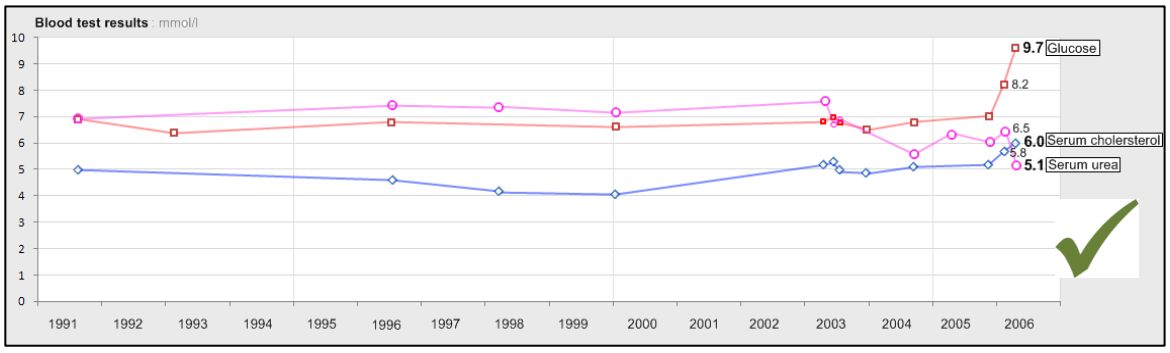




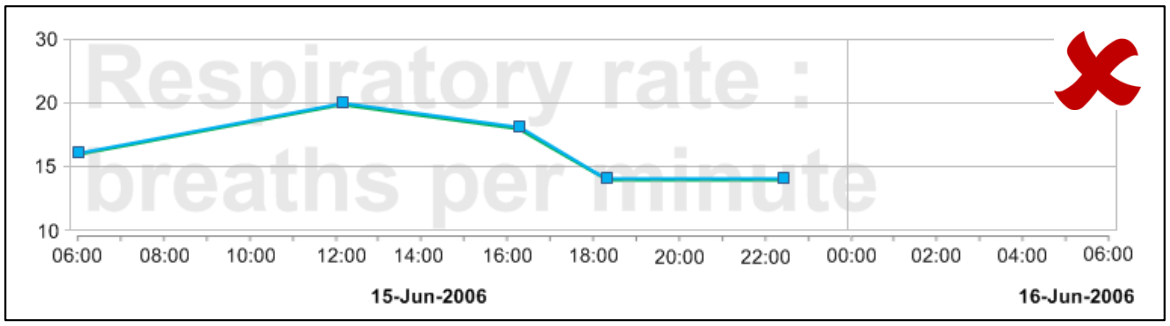
Example 18: Do not display labels vertically



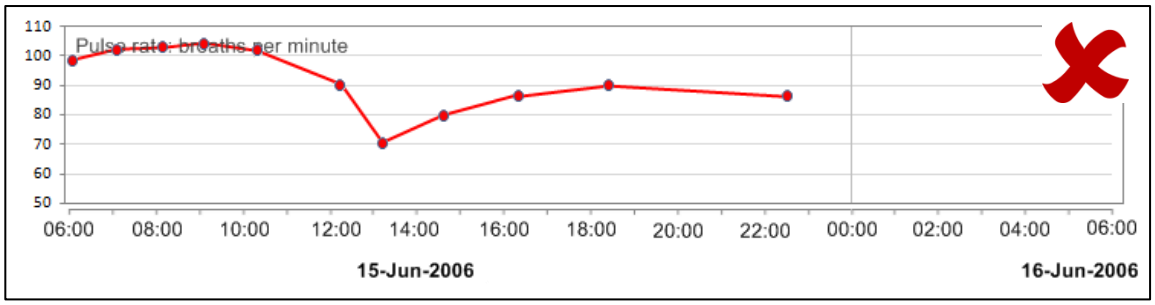
Example 19: Label next to the data series



Example 20: Do not feature a watermark



Example 21: Do not feature text behind the data



Rationale

Clear textual labelling is essential as there is nothing inherent within the graphic that identifies the underlying data (with the exception in some cases of blood pressure).

EN ISO 9421-12:1998 states that 'Screen elements (for example, fields, items, icons and graphs) should be labelled unless their meaning is obvious and can be understood clearly by the intended users' **{R17}**.

Confusing data series could have severe consequences on patient health and safety. Therefore, each data display needs to be clearly labelled.

As a general principle, it is better to locate the label close to the data series. This heuristic of 'proximity' is articulated in Gestalt theory of perception as a key way in which humans perceptually group objects **{R7, R8}**. There is also less room for erroneously associating the wrong label to a data series. This risk is increased as the label is moved away from the data or requires an additional level of cognitive processing (as in the case of matching up a data series format with a separate legend). However, placing a label immediately next to the data points can obscure the data if placed in the graph area. Also, it is easier to scan down a list of aligned textual labels in a uniform position (for example, on the left hand side). For this reason, we recommend that labels are positioned at the top left-hand corner of each graph area.

Studies have shown that people find it more difficult to read text that is oriented vertically. Indeed, the relevant BSI standard **{R2)** indicates that vertical text should be avoided. Therefore, avoid the vertical labelling of axes.

Displaying the label as a watermark behind the data within the graph area is problematic. The Royal National Institute of Blind People (RNIB) recommend that text written on images (and, by extension, text written underneath images) should be avoided as people with dyslexia find it harder to read such text[2]. The watermarks can be a problem also for people without such reading difficulties as the text could interfere with the accurate reading of the data points.

In the event of multiple overlay of data, we would recommend that the labels are located at the end of each data series. However, writing labels vertically is problematic as it harder for people to read text oriented in this way.

Solutions featuring labelling at the top and next to the data series have been shown to clinicians as part of the CUI research programme with no clinician misidentifying the data with either of these types of labelling **{R5, R6}**.

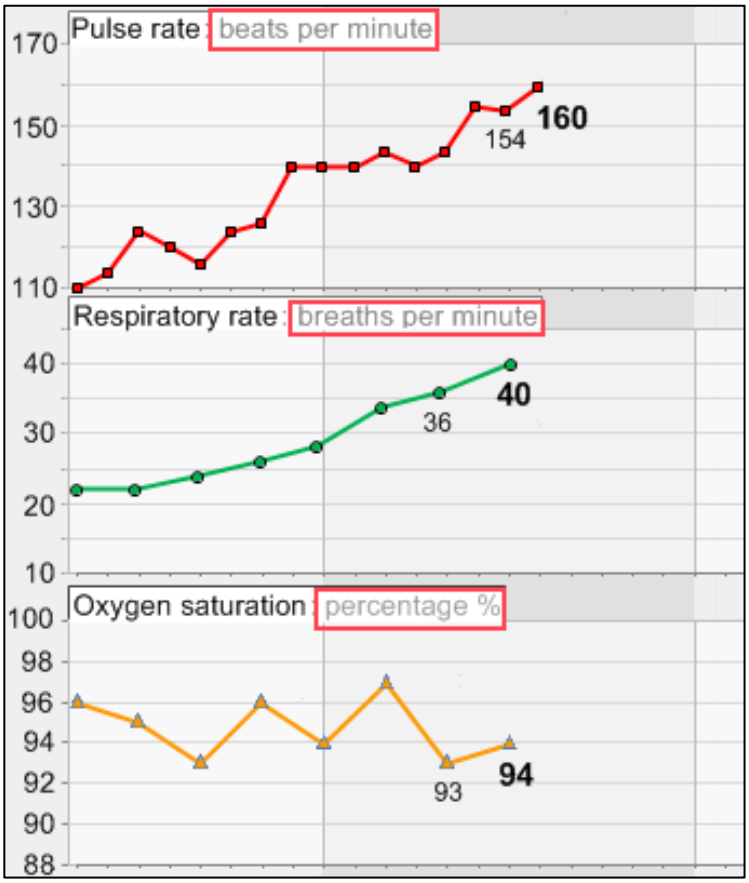
[2] Royal National Institute for Blind People: See it Right guidelines **{R16}**: http://www.rnib.org.uk/xpedio/groups/public/documents/publicwebsite/public_seeitright.hcsp

2.3 Guidelines – Displaying Data Units

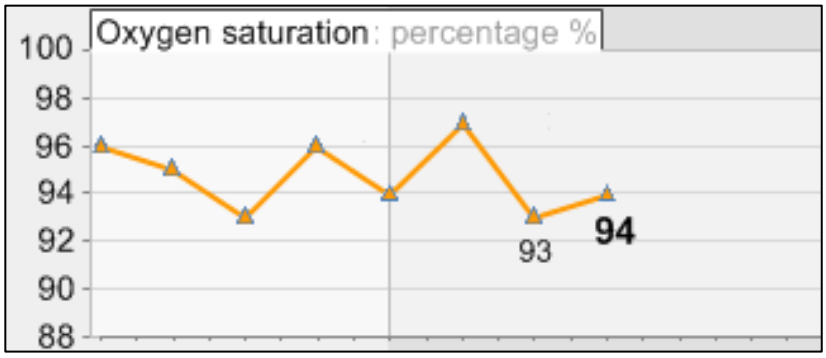
ID	Description	Conformance	Evidence Rating
GTAB-027	Data unit labels must be visible at all times that a data series is graphed (Example 22)	Mandatory	High
GTAB-028	Do not display values taken with different units of measurement in the same series of data values. In these cases, separate data value series are required (with separate axes) (Example 26)	Mandatory	Low
GTAB-029	Do not display values taken with different units in the same sequence of data values in a table (either displayed in a column or in a row)	Mandatory	Low
GTAB-030	If data values have been converted from one unit to another, the system must clearly communicate that this has happened at the level of the data value points	Mandatory	Low
GTAB-031	Data unit labels may be expressed as abbreviations (such as 'mmHg')	Recommended	High
GTAB-032	Where they are available, use standard abbreviations (such as '°C')	Mandatory	Low
GTAB-033	Abbreviations for data units should not be used where the abbreviations for two separate data units are the same For example, 'BPM' should not be used for 'Beats Per Minute' **and** 'Breaths Per Minute'	Mandatory	Low
GTAB-034	The system should provide definitions of any abbreviated data units upon request (Example 27)	Mandatory	High
GTAB-035	The system could provide full data unit definitions as hover-overs (Example 27)	Recommended	Low
GTAB-036	Data units should be displayed alongside the data series labels For example, the data axis label and the main data series label (Example 23)	Recommended	Medium
GTAB-037	Data unit labels can be displayed in a less prominent font size or weight than the data type labels (Example 23, Example 25)	Recommended	Medium
GTAB-038	Data units do not need to be displayed next to each data value (Example 24)	Recommended	Low

Usage Examples

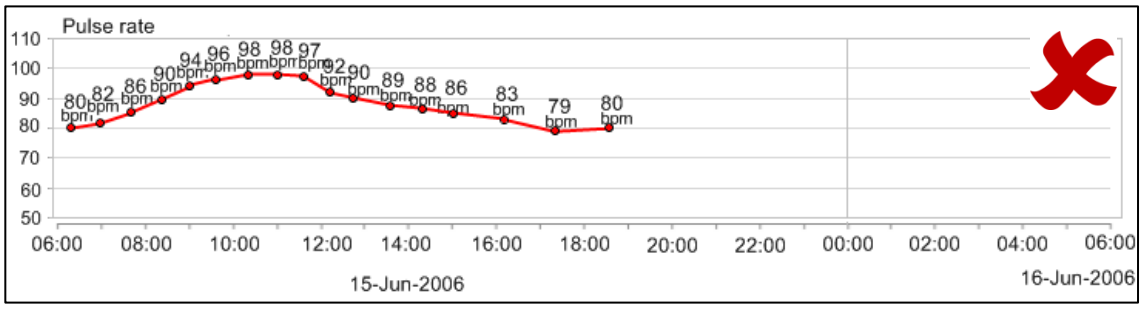
Example 22: Display units for each data series (emphasised here by the red box)



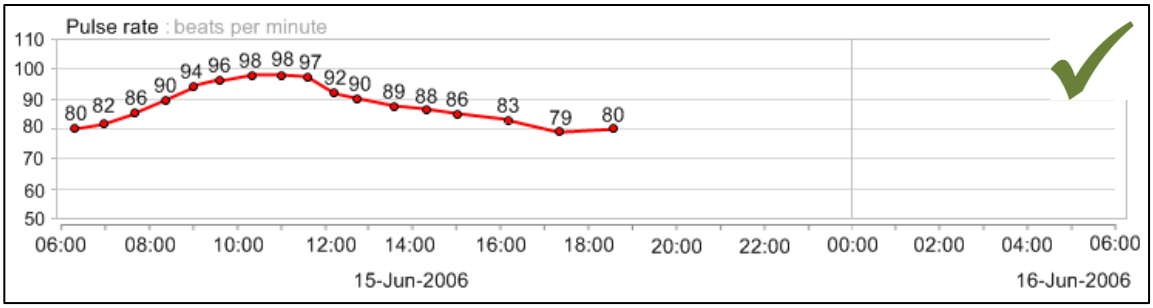
Example 23: Feature the data unit label next to the data type label in a less prominent format



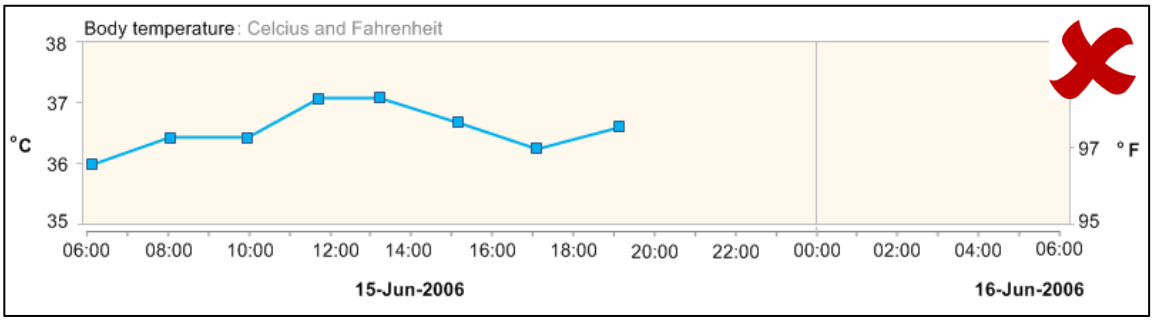
Example 24: Do not display all data unit labels next to each data point as they obscure the data



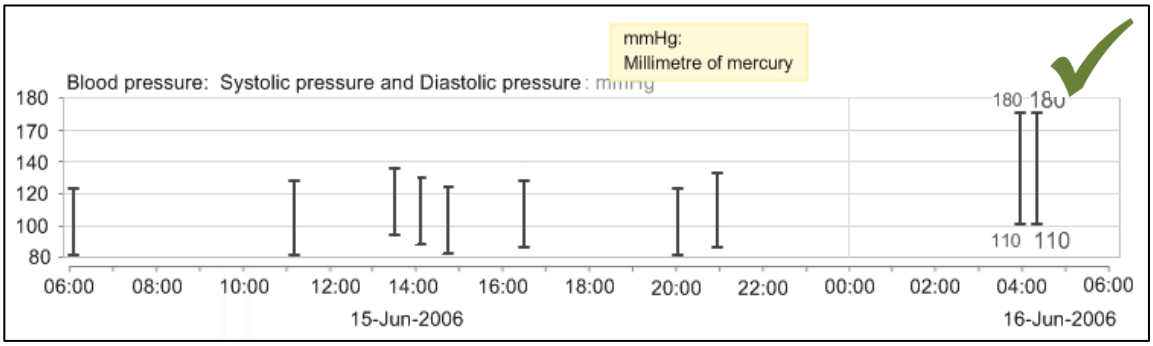
Example 25: The unit presented in the header applies to all the values displayed in the graph area



Example 26: Do not display different data units – Celsius then Fahrenheit



Example 27: Provide hover-over display to fully display the unit



Rationale

The display of units is very important if the data is to be interpreted correctly. A number of data series could be measured in multiple units (for example, temperature can be measured in Celsius or in Fahrenheit). Also, as measuring technology is refined and developed over time, periodically units of measurement are replaced. Without units explicitly labelled, there may be scope for misinterpretation, which in turn could compromise patient safety.

Also, the unit of measurement can help to define the data series itself. For example, knowing that oxygen saturation data is expressed as a percentage means it is less likely to be confused with other measures of oxygen, such as litres of oxygen being administered to the patient.

During our design exploration, we looked at a number of ways of displaying the units and the clearest way was to display them as part of the main data label.

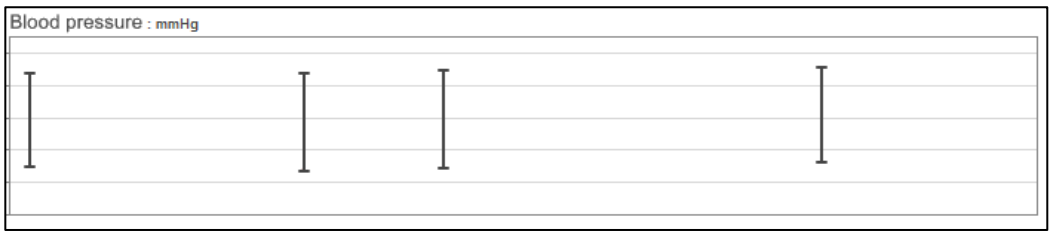
During the CUI research **{R5, R6}**, clinicians were presented with the units displayed next to the data type labels in a less prominent format and they neither misinterpreted the data nor felt that the labelling was confusing or obstructive in this position.

2.4 Guidelines – Displaying Blood Pressure Composites

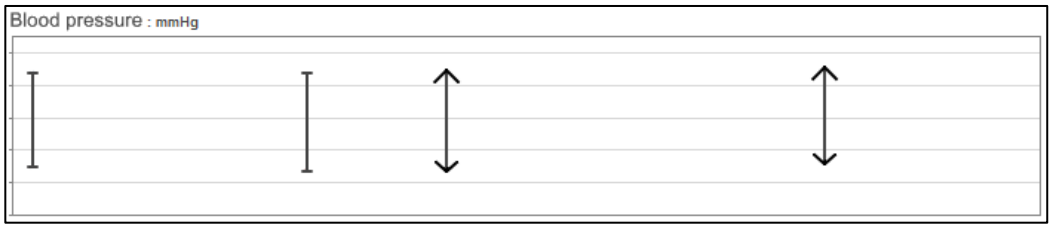
ID	Description	Conformance	Evidence Rating
GTAB-039	Systolic and diastolic blood pressures should be displayed on the same graph area (Example 28)	Mandatory	High
GTAB-040	Systolic and diastolic blood pressures should be displayed as opposite ends of a vertical line (Example 28)	Mandatory	High
GTAB-041	The intersection points (that is, the intersection between the x and y axes) for both systolic and diastolic pressures should be represented by a short horizontal bar, thus creating a double-ended 'T' **Note** Arrow-heads are also acceptable, as outlined in the rationale below.	Recommended	Medium
GTAB-042	The short horizontal bar which aligns with the y-axis values of the systolic and diastolic pressures should be a little thicker than any gridlines overlaid on the graph area	Mandatory	Medium
GTAB-043	Do not interpolate the blood pressure data points without the vertical lines connecting the systolic and diastolic pressure values	Recommended	Medium
GTAB-044	When data points are positioned tightly together, the symbol becomes a straight vertical line between the systolic and diastolic values	Recommended	Low

Usage Examples

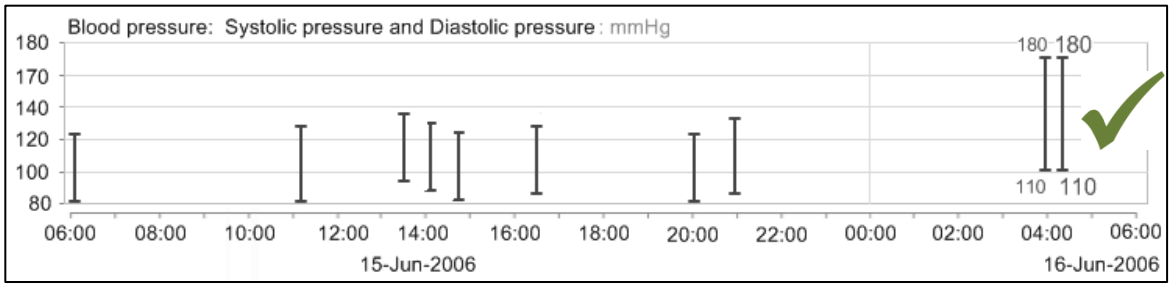
Example 28: Feature T-bars to represent blood pressure



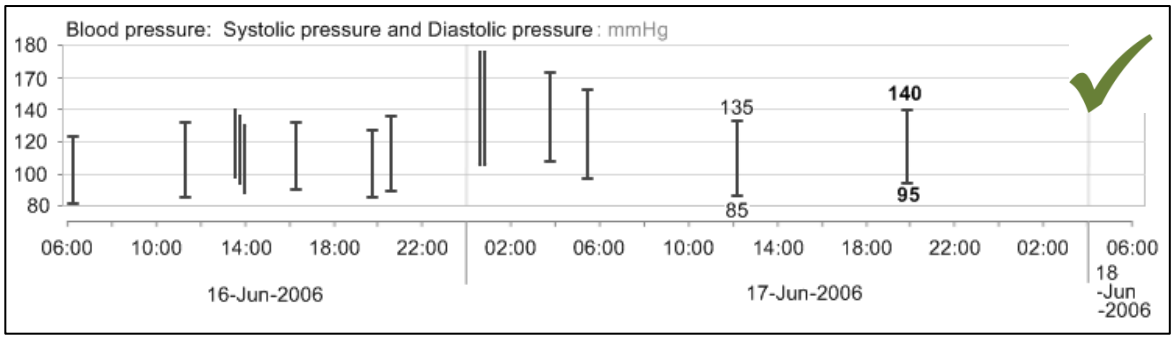
Example 29: Do not feature arrowheads alongside T-bars



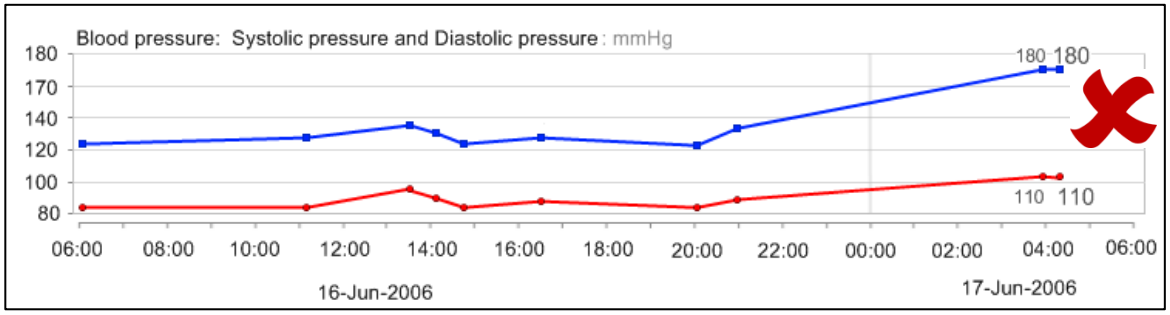
Example 30: Display blood pressure with T-bars



Example 31: Use a straight line symbol for tightly-packed pressure bars



Example 32: Do not display blood pressure as interpolated data points without links between systolic and diastolic pressures



Rationale

CUI user research and desk research has found that clinicians expect that the systolic and diastolic elements of blood pressure should be displayed in the same graph area and should be visually linked together **{R5}**. Although we found some instances where the data points for both data were interpolated, the universal manner of displaying them was to show them as either arrow-heads or T-bars connected by a straight line.

We do not recommend that the data is never interpolated, as there are some situations where interpolation can improve the interpretation of highly variable data. However, as a default, we recommend that the vertical line approach is adopted.

We also recommend the use of T-bars over arrow-heads, given the slight potential for misinterpreting the data with arrow-heads, especially if the arrow-heads are shown at a low resolution or in a zoomed-out view. In these cases it may be unclear as to the precise point at which the data lies. Also, arrow-heads that point outwards have the effect of making the line seem smaller than it is. This effect is exaggerated if there are also lines with arrow-heads pointing inwards (the 'Muller-Lyer' effect **{R7}**) and a combination of the two should definitely be avoided.

It is clear from the T-bars where the data point lies (if the horizontal of the bar is thicker than any horizontal gridlines) and it is easier for the viewer to align the y-value with the y-axis as they can follow the plane along from the horizontal line of the 'T'.

Arrow-heads are familiar to clinicians, but are better suited for paper charting where, given the use of fairly heavy gridlines, the arrow is required for the data points to stand out against the horizontal gridlines.

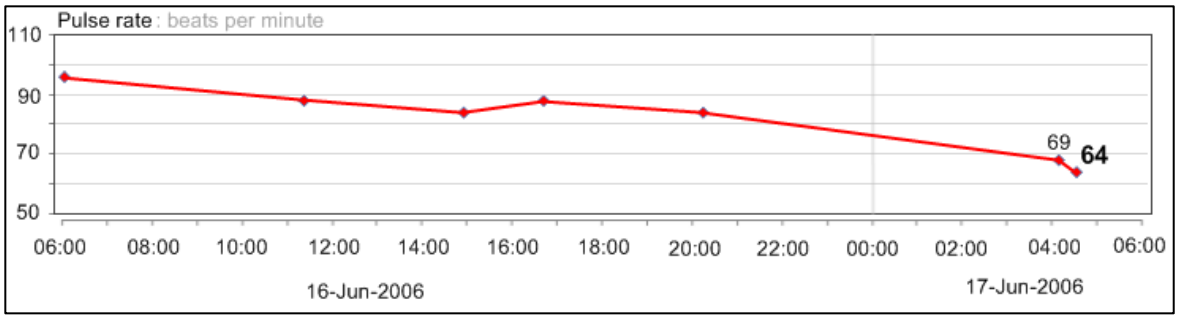
Recent patient safety analyses **{R5, R6}** showed that there no significant patient safety risks associated with using either symbol. It is also recognised that arrows are widely used in current practice and are familiar to clinicians. Therefore, we recommend the use of T-bars, for the reasons stated above, but recognise arrow-heads as an acceptable alternative.

2.5 Guidelines – Displaying Textual-Numerical Values in Graphs

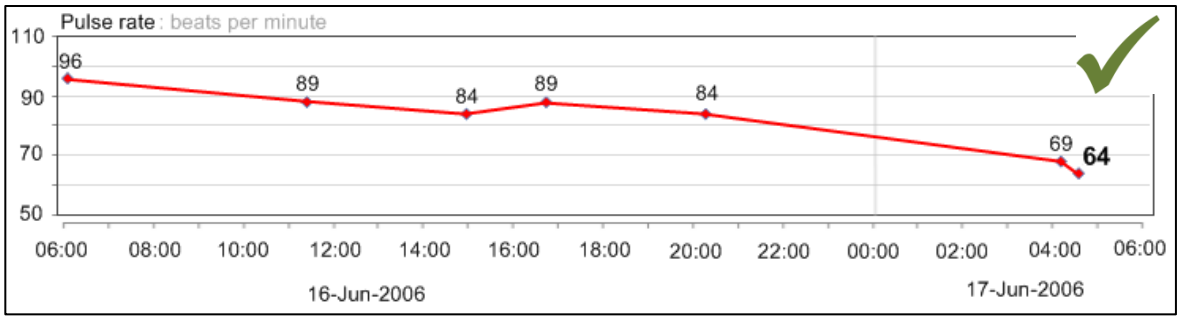
ID	Description	Conformance	Evidence Rating
GTAB-045	Display the most recent numerical value for each data series by default	Mandatory	High
GTAB-046	Display the penultimate numerical value for each data series by default (Example 33)	Mandatory	High
GTAB-047	Feature the most recent numerical value for each data series in a larger and/or heavier font (Example 33)	Mandatory	Medium
GTAB-048	Do not display all numerical values for a data series by default	Mandatory	Medium
GTAB-049	Allow the display of all the numerical values for a data series, upon request by the user (Example 34)	Mandatory	High
GTAB-050	Allow the display of any single numerical value, upon request by the user	Mandatory	Medium
GTAB-051	Display the numerical values adjacent to the graphical data points (Example 34)	Mandatory	Medium
GTAB-052	Display the numerical values in a consistent position in relation to the graphical data points (Example 34)	Mandatory	Low
GTAB-053	Display the numerical values above or below the data points	Recommended	Low
GTAB-054	Display the numerical values to the precision in which they were recorded For example, to the nearest integer, to one decimal place	Mandatory	Low
GTAB-055	Feature the numerical values in a reasonably-sized font, namely based upon the prevailing good accessibility practice	Recommended	High
GTAB-056	Feature the numerical values in a clear, undecorated typeface (Example 35)	Recommended	Medium

Usage Examples

Example 33: Display the most recent values



Example 34: Display all of the values at the same time, if the user has requested it



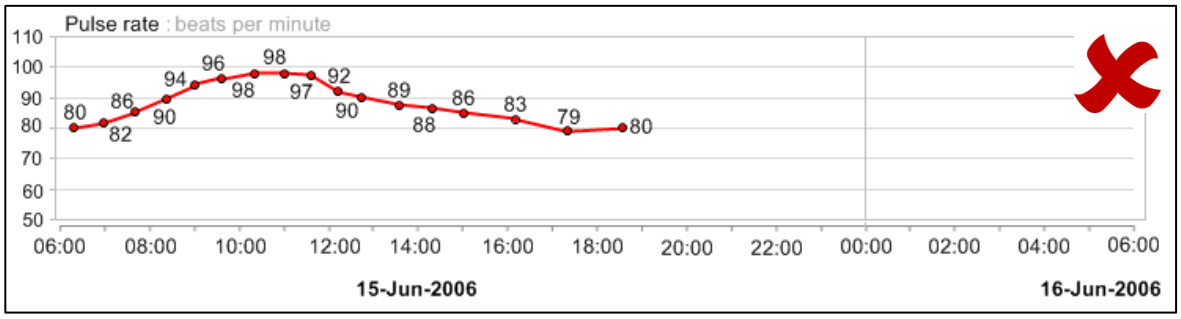
Example 35: Feature clear, undecorated typefaces

Pulse rate

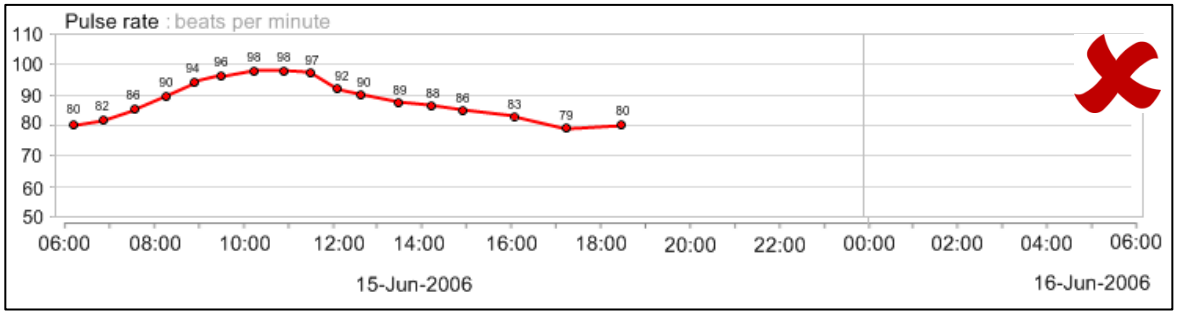
Pulse rate

Pulse rate

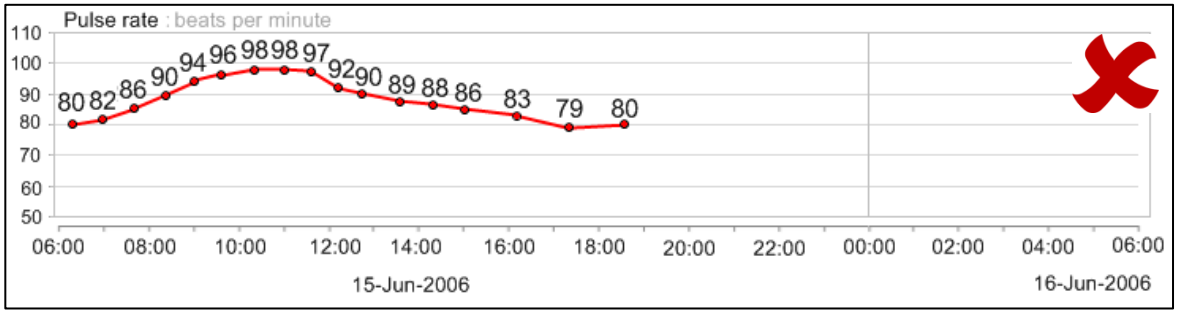
Example 36: Do not display values in inconsistent positions



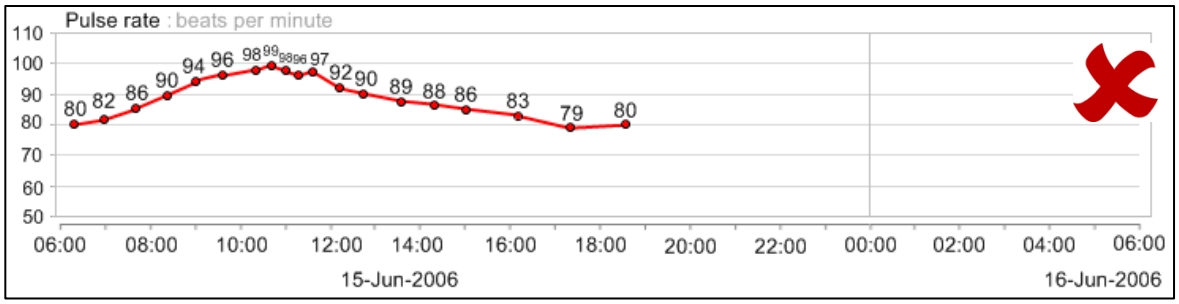
Example 37: Do not display values in too small a font size



Example 38: Do not display value in too big a font size

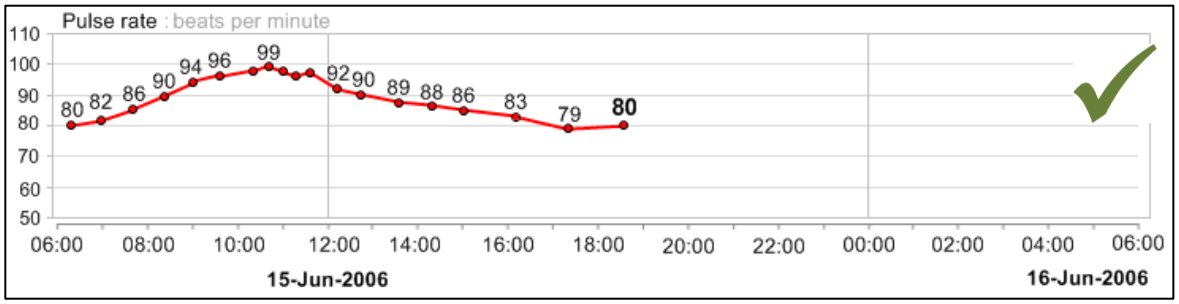


Example 39: Do not display too tightly packed data



This is a problem because the user may misinterpret the data displayed in the small font.

Example 40: Display the label for the peak value in the tightly packed data



Rationale

Displaying the current (or at least the most recent) value is important as this is often the information that the user needs to see first along with how much it has changed since the penultimate value. Such a mechanism is often found on medical telemetry systems that record and display vital signs information in hospitals.

Our CUI research interviews **{R5}** indicated that staff made use of this function. In user tests, the majority of clinicians indicated that this would be a useful feature.

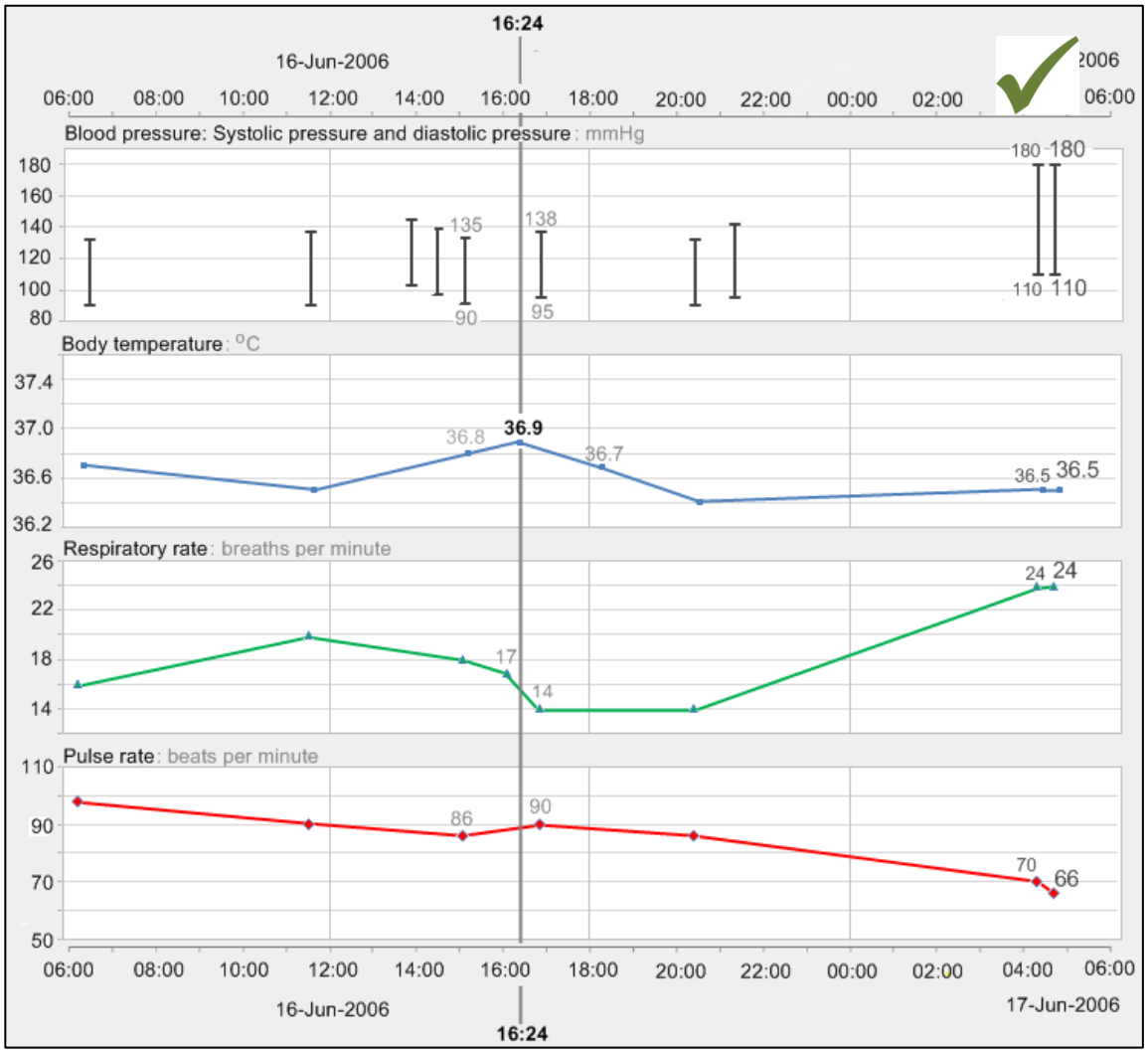
Text size must not be displayed below a minimum size **{R11}**, so that it is to be clearly viewable. However, text that is too large can hinder its reading as overlapping can occur and the text can detract from the graphical elements of the graph.

2.6 Guidelines – Focus of Data Points

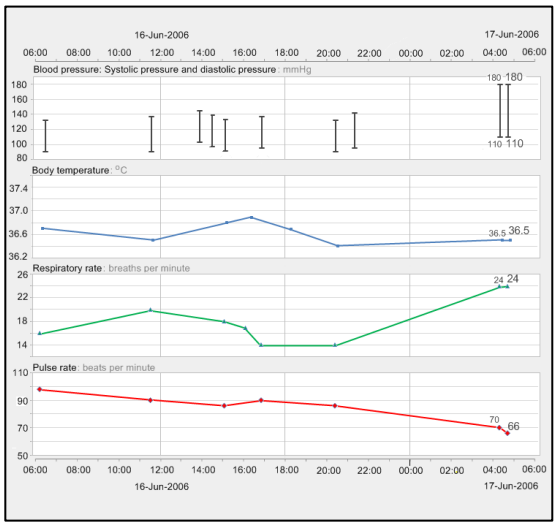
ID	Description	Conformance	Evidence Rating
GTAB-057	Provide a visual focus line that spans all data series and that is aligned to a chosen time. When the focus line crosses a value point, display the appropriate value label (Example 41)	Mandatory	High
GTAB-058	Allow some tolerance in the focus line, so that a data point will be picked up even if it does not precisely align with the vertical line. The level of tolerance will depend upon the clinical context, and upon the granularity of the time intervals	Recommended	Low
GTAB-059	When the focus line crosses the value point, provide a background to the value label so that it is not obscured by the line	Recommended	Low
GTAB-060	For each data series, allow the user to reveal the value immediately preceding and the value immediately following the specific point in time, within a set tolerance	Recommended	Low
GTAB-061	Distinguish the values that are aligned with the focus line from the preceding and following values (Example 41) Make the aligned value more prominent through font weight and font size	Recommended	Low
GTAB-062	The visual focus can be moved between times or time ranges by the user (Example 42)	Mandatory	High
GTAB-063	The visual focus can be moved by moving the mouse over the top of the graph areas (Example 42)	Recommended	Low
GTAB-064	The visual focus can be moved by button presses and/or key presses: one for tabbing forward and one for tabbing back	Mandatory	Low
GTAB-065	The visual focus line should be labelled with the time with which it is aligned (Example 41)	Mandatory	Medium

Usage Examples

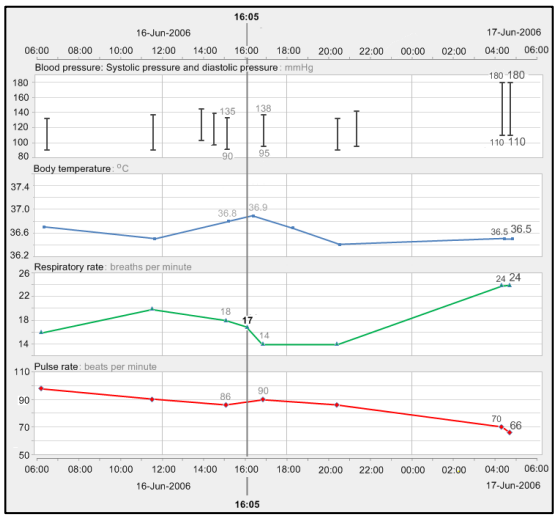
Example 41: Provide a vertical focus line that reveals the values of all of the data points that intersect with it

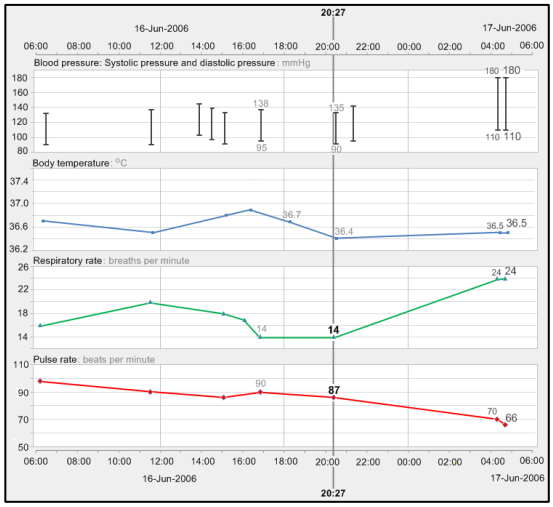


Example 42: Outline of how the focus will work



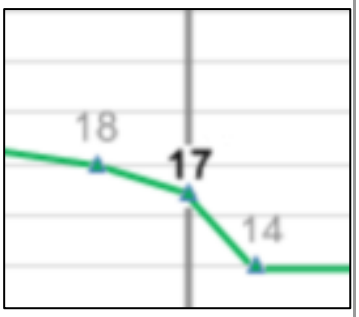
Step 1: Initially the clinician has the mouse away from the graph areas. None of the values are in focus.





Step 2: The clinician drags the mouse over the graph and the vertical line appears on the same vertical plane as the mouse cursor. The corresponding numerical values are shown for all datapoints which intersect or that fall within a given tolerance of the vertical line.

Also, for each data series, values are shown for the data points preceding and following the vertical line, but less prominently (as shown on the right).



Step 3: As the clinician moves the mouse horizontally over the graph area, the vertical line moves, revealing further data values.

Rationale

From interviews with clinicians, we ascertained that they often need to be able to identify the values for a number of data series simultaneously in order to give a 'snapshot' of the patient's observations at a given point in time. In some cases, a clinician may draw a line down the observations chart in order to align the values at a given time.

Therefore a 'focus' function is required that spans multiple values. The CUI research team presented this concept to clinicians and received positive feedback for it.

The main issue in designing such a focus is that values which a clinician considers simultaneous may not have been recorded at exactly the same time. For example, a set of observations taken as part of a four-hourly observations cycle at approximately 18:00 may comprise readings taken and recorded at 17:58, 18:00, 18:02, 18:03 and 18:04. If the focus is aligned to a specific time, such as to the minute, the clinician would not be able to view a set of observations simultaneously. Therefore, there should be some tolerance in the focus, while it clearly communicates the exact time to which it is aligned and any readings that align exactly to it.

Displaying the preceding and following data values also serve the additional function of allowing the clinician to see the direction of the data that a given point represents (that is, whether the focal value represents a rise or a fall in the data).

The CUI research **{R6}** indicated that the current focus design was preferred to alternative designs.

3 SCALING GUIDANCE DETAILS

Scaling refers to the mapping of numeric intervals in the underlying data onto physical distances in the graph area. In other words, a scale provides a means of assigning specific values to the data points on the graph, based upon their location along the scale lines.

For example, an hour may be represented by a distance of 10 mm running from left-to-right along the (horizontal) x-axis while a rise of 0.5º centigrade of body temperature may be represented by 5mm running from bottom-to-top along the (vertical) y-axis.

The current guidance addresses both the x-axis and y-axis scales in combination as this has importance in dictating the 'shape' of the pattern formed by the location of the data points, which can influence clinicians' interpretation of the underlying data.

The guidance assumes a 'common', linear scaling rather than a non-linear scaling for the observations data, as the quantitative interval from one axis marking to the next is always the same. Non-linear scaling, such as 'logarithmic' scaling, may have uses in clinical graphing, but analysis has not identified reasons for their inclusion when measuring the physiological 'vital signs' that are in scope for the current guidance.

3.1 Guidelines – Scaling

ID	Description	Conformance	Evidence Rating
GTAB-066	There should be a linear relationship between data values and their spatial location That is, within a view, a unit of time is consistently represented by a set distance and a unit of clinical measurement is consistently measured by another set distance (Example 43, Example 44)	Mandatory	High
GTAB-067	In the default view of a graph, the time-axis should be scaled to one of a set of pre-defined time ranges	Mandatory	Medium
GTAB-068	Ensure that for each default timescale, there is a ratio of x-axis to y-axis that is consistently applied	Mandatory	High

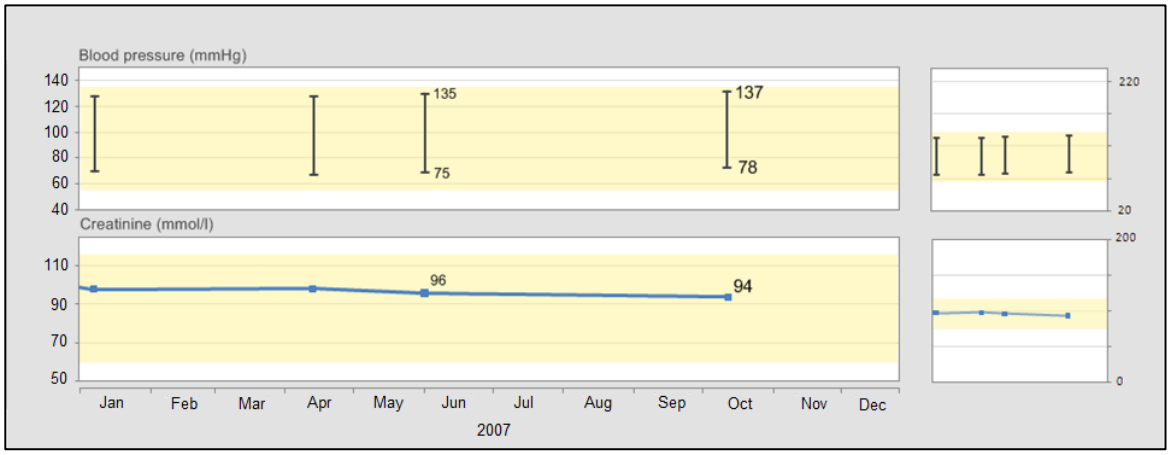
GTAB-069	The y-axis scale should be pre-determined by considering a number of factors
	The factors are:
	▪ Vertical space available in the area allocated for graphing in the application
	▪ Total possible range of measurements
	▪ Likely range in the specific population for that context
	▪ Whether an early warning scoring system applies to the graph and the parameters of this scoring
	▪ 'Normal range', which defines the parameters outside of which the reading is 'abnormal' and a cause for concern:
	  ▪ Whether various patient attributes will determine the parameters of the normal range
	  ▪ Whether the normal range may change over time (for example, with the patient's age)
	▪ What is a significant degree of change that the clinician must detect from the graph (for example, does a rise of 0.1, 1 or 10 matter)?
	▪ The likely range of variation in a given patient
	▪ How likely is the occurrence of genuine outlier values?
	▪ The extent to which any of these factors vary depending upon the context
		Mandatory	High

ID	Description	Conformance	Evidence Rating
GTAB-070	Where a normal range is to be shown on the graph area, the default graph view must be sufficiently high to show the normal range plus a margin The margin may be such as a minimum of 10% above and below the normal range An exception to this guideline is where the normal range extends to the highest or lowest possible value, such as in the case of oxygen saturations, where the normal range extends up to 100% See section 8 for a more detailed discussion on the display of ranges.	Recommended	High
GTAB-071	Ensure that, in the default view, the clinically significant changes (rises or falls) are always detectable by the clinician	Mandatory	High
GTAB-072	In the default view, do not optimise the view by maximising the size of the data to fill the graph area	Mandatory	High
GTAB-073	Allow the user to choose to optimise the view (that is, maximising the data to fill the graph area)	Recommended	Medium
GTAB-074	If re-scaling is required, minimise the number of scale gradations and/or the number of re-scaling steps	Recommended	Low
GTAB-075	Upon re-scaling from a default view scale, the system should display that the view is re-scaled	Mandatory	Low
GTAB-076	In the event that, on a given scaling, the data requires more space than is available, re-display according to certain priorities Follow one of these options (in order of priority): ▪ Expand the graph space up or down to accommodate the full range of data ▪ Shift the graph space axis to accommodate the most recent data. In determining the parameters of the axis, give priority to recent over older data ▪ Snap the graph space to another pre-defined scale. This solution would need to discount outliers, the criteria being determined by clinical need	Recommended	Medium
GTAB-077	If the scaling solution is based upon a shift up or down along an axis, provide a scroll feature when data falls outside of the visible axis range	Recommended	Medium
GTAB-078	If the scaling solution is based upon a shift in axis, where data may fall outside of the visible range, provide a mechanism that communicates all the data within the given timeframe	Mandatory	High
GTAB-079	A thumbnail can be used to communicate all the data within a given timeframe if the main graph area does not show all the data simultaneously (Example 46)	Recommended	Medium
GTAB-080	Where possible, show the data points on the thumbnail. However, for large timescales containing much data where this is not possible, just show interpolation (Example 46)	Recommended	Medium
GTAB-081	Display the upper and lower axis 'tick' marks on the thumbnail (Example 46) The tick marks are the scale's incremental markers (for example, where each tick represents a period of time)	Recommended	High
GTAB-082	Do not position the thumbnail in a position that obstructs the main graph (Example 46)	Mandatory	Medium
GTAB-083	Where appropriate, overlay an indicative range or line. Display this both on the main graph area and the thumbnail For example, an indicative range may be a normal range, the normal value or early warning parameters	Recommended	High

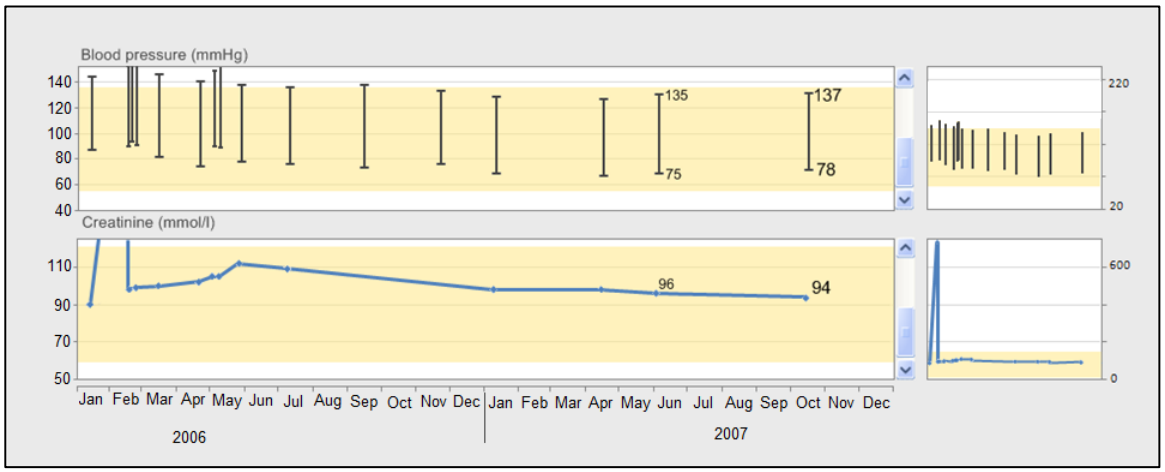
Usage Examples

Example 43: Maintain consistent scaling (different time views)

Step 1: One year view

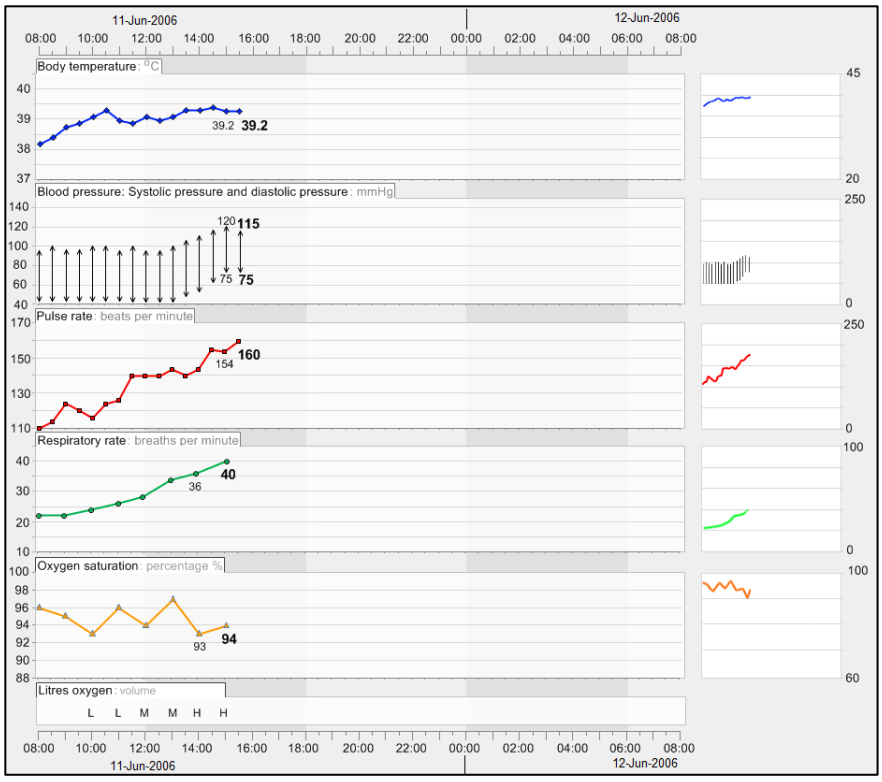


Step 2: Two year view

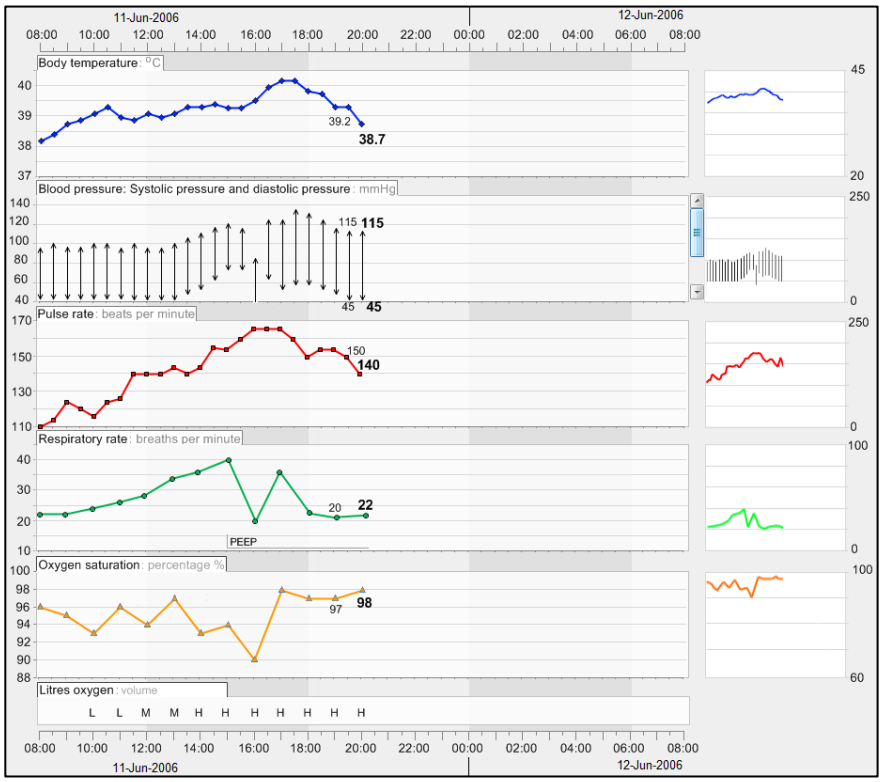


Example 44: Maintain consistent scaling (as time passes)

Step 1: Patient's chart at 16:00

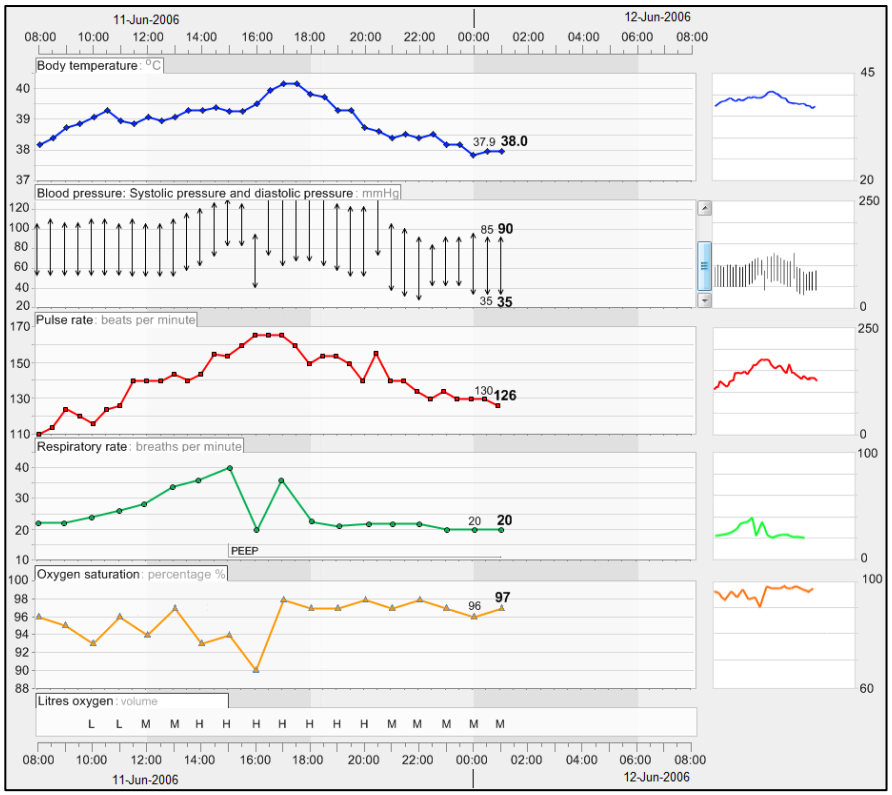


Step 2: Patient's chart at 20:00



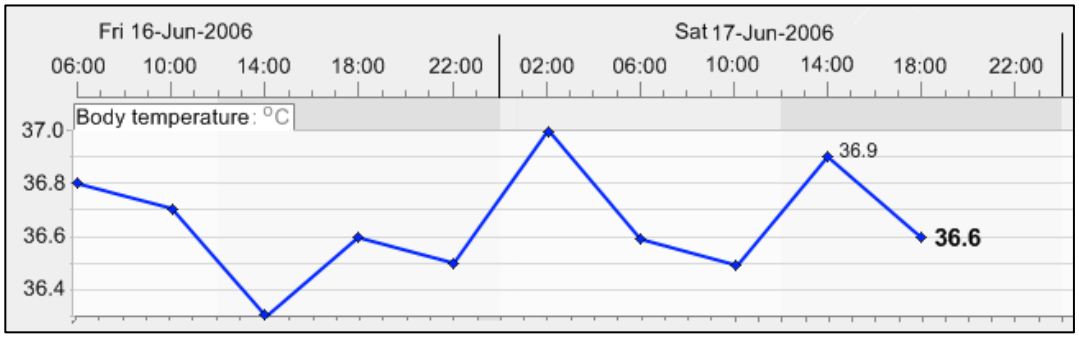
As more data is added, the scaling remains the same. This means that part of the blood pressure (second graph from top) is out of view and requires scrolling to view one of the data points. This problem is mitigated by providing an overview in the right-hand thumbnail, in which the clinician can see all the data for all the measurements in the timeframe.

Step 3: Patient's chart at 01:30



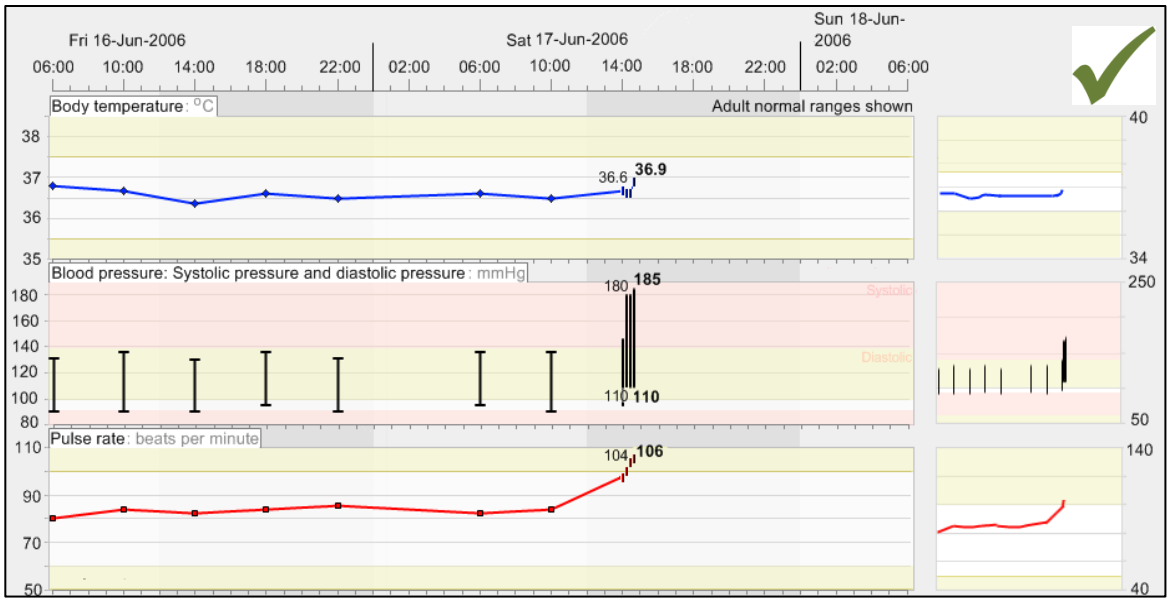
In the final diagram, the blood pressure has dropped over time and therefore some of the data has scrolled out of the top of the chart as the graph window has effectively moved down. This problem may be mitigated better by providing a larger graph space or by starting off with a reduced scale in which more data can fit. This type of decision should be made in the context of expected ranges and fluctuations of data for a given clinical setting. However, if multiple graphs are shown simultaneously there will always be the risk that some data that cannot fit in the default scale and the above solution shows how to mitigate against this risk.

Example 45: Do not automatically change the scale so that the data points expand to fit the graph area by default



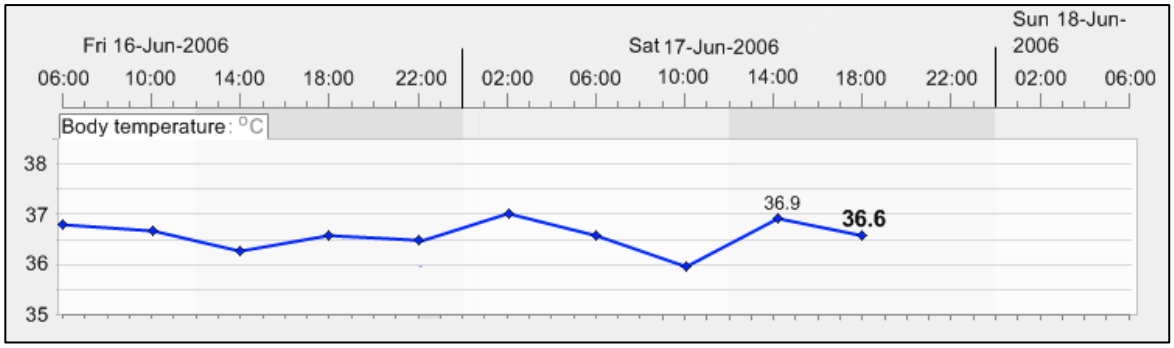
Although many graphing software packages automatically expand the data to fit the graph area, in a clinical context where quick recognition of patterns and the ongoing monitoring of a single patient's data is important, it is more important to display data according to a consistent scale. If the scale keeps changing, it is hard to keep track of the data patterns over time. Also, maximising the differences with the data could lead to clinicians thinking there are problems when no problems exist and, eventually, becoming sensitised to potentially significant changes.

Example 46: Feature thumbnails (right hand side) and normal ranges to orient the viewer

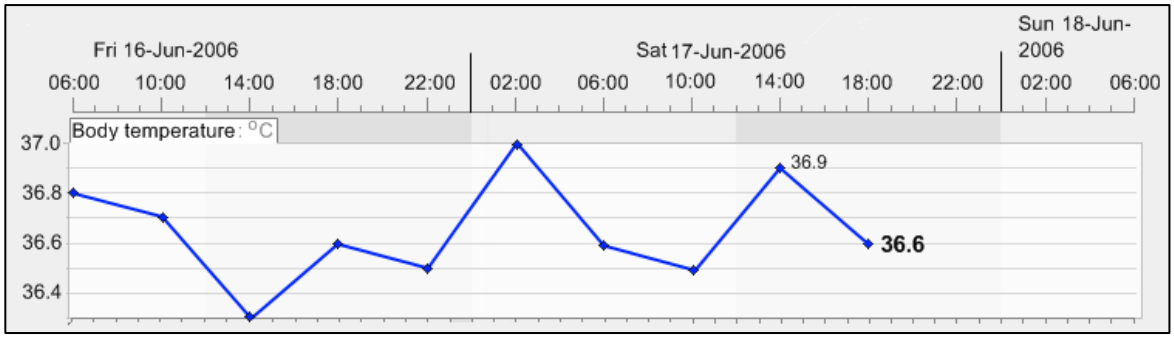


Example 47: Allow the user to choose to maximise the view (not by default)

Step 1: Normal, consistently-scaled view (default)



Step 2: Maximised view, so that the data expands to fit the graph area (user chosen)



The example above shows how a 'maximise' data view could work. Step 1 shows the normal default view, which would be consistently scaled according to the timescale. As new data is added, the scale does not change. However, the user would be offered a mechanism to expand the data to fit the graph area in order to see as much change as possible. Step 2 shows this maximised view.

Rationale

A number of studies have underlined the importance of scaling and the, potentially negative, impact it can have on clinical decision-making. For example, Cartmill and Thornton's 1992 study **{R14}** of the effect of the proportions or aspect ratios of graphs upon obstetricians revealed that changing the ratios of x-axis to y-axis of partograms for the same cervical dilation data over time led to clinicians suggesting different clinical decisions. When the graph was flatter, the clinicians thought that cervical dilation was occurring very slowly and decided to intervene in twice as many patients as when the same data was displayed on the taller graphs that the doctors had been trained with. Tay and Yong report that this effect was repeated in further studies, even when the doctor's training had been with the flatter graph **{R20}**. This effect was also mirrored by the CUI research findings, which found that clinicians overestimated physiological effects where the scaling of the ratio of x-axis to y-axis was taller **{R11}**.

As clinicians' decision-making can be influenced by the scaling of graphs, in particular with the difference between flatter and taller ratios, then graphs should strive for consistent scaling. Consistency should minimise the risk of misinterpreting the shape of a graph. Clinicians get used to seeing and interpreting shapes and patterns and therefore inconsistency could lead them to wrongly consider the current situation to be similar or different to past situations. The main challenge of maintaining consistency of scaling is that data values can fluctuate a lot within a given data series. For example, in one instance pulse rate may be varying between 60-90 beats per minute but in another situation the pulse rate may be reading between 120-150 beats per minute. It could be important to be able to detect slight changes within either of these two ranges. Within a short timeframe the patient's pulse rate could also rise between these two ranges.

A CUI study concluded that consistent scaling was necessary to avoid misinterpretation of clinical data **{R5, R6}**. Researchers compared clinicians' responses to consistently scaled graphs versus their responses to 'maximised' scale graphs (that is, a scale which presents the data range as large as possible within the graph area). They found that:

- The majority of clinicians tended to overestimate changes when they viewed a maximised scale
- In the maximised version, large differences within a data series can mask more subtle (but significant) changes
- Clinicians did not like the fact that some data may not be visible in the consistently-scaled version
- The provision of additional thumbnails to show all the data for a given timeframe meant that clinicians were aware of all the data, even though extreme values were not immediately visible in the main graph area. However, clinicians felt that it would be useful to see how many values were out of view.

The study recommended that:

- Consistent scaling should be ensured as far as possible
- Default scaling should feature an axis that allows for typical rises and falls in the data while ensuring that the data remains in view
- Shifts in the axis (either up, down or re-scaling) should be accompanied by a feature which mitigates against the clinician becoming disoriented (such as thumbnails showing the full range of data and consistent markings on the graph area providing a consistent point of reference)

Reference ranges are an important point of orientation in a graph. They can and should be displayed but, where appropriate, adjusted to the specific patient population (for example, do not display an adult normal pulse range when the patient is a child)

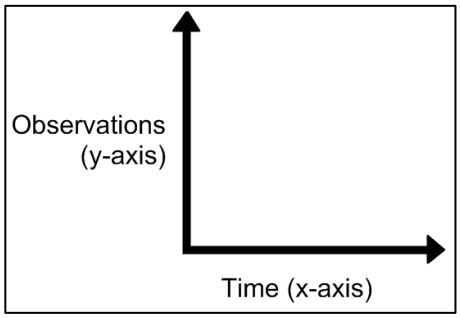
4 Axes Guidance Details

4.1 Guidelines – X-Axis and Y-Axis Arrangements

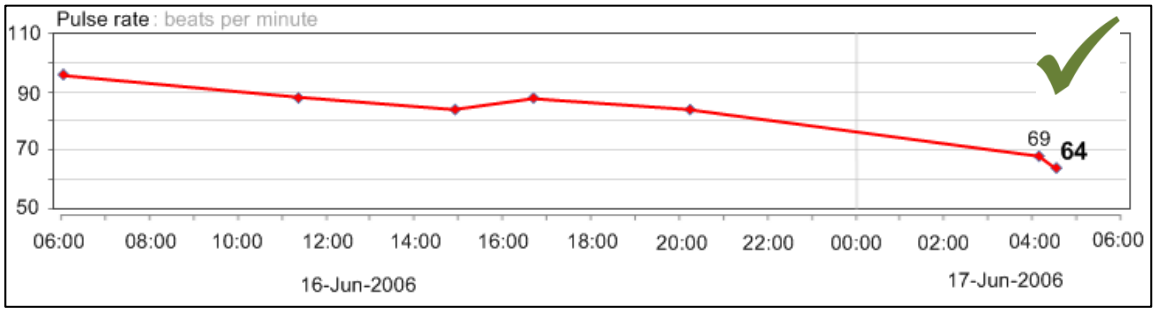
ID	Description	Conformance	Evidence Rating
GTAB-084	If time is displayed as one of the axes, it should be displayed along the (horizontal) x-axis. (Example 48, Example 49)	Mandatory	High

Usage Examples

Example 48: Use the x-axis to display time



Example 49: Correct graph display with time running along the x-axis from left to right



Rationale

Artefact evidence, such as existing forms, along with CUI user research, has shown that clinicians expect to see time along the x-axis rather than on the y-axis. Breaking the convention would be dangerous as there is a risk of clinician misinterpretation.

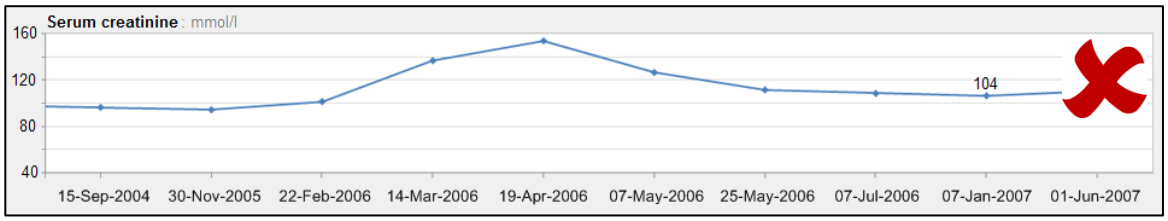
The display of time in this way is best practice generally and not just in the clinical domain **{R8, R9}**.

4.2 Guidelines – Time Axis Intervals

ID	Description	Conformance	Evidence Rating
GTAB-085	As a default, time must be displayed proportionally in observation graphs (Example 51) That is, each time interval (such as one hour) must be represented as a distance (such as 10 mm). In each view of the graph data, the relationship between time interval and distance must remain consistent (for example, the distance between 14:00 to 15:00 will be the same as that between 15:00 to 16:00)	Mandatory	High
GTAB-086	As a default, do not display data values non-proportionally along the time axis (Example 50) That is, do not represent a time interval (such as a day) as the same distance as another time interval (such as an hour)	Mandatory	High
GTAB-087	Mark the time intervals (that is, use hour marks, day marks, week marks and so on) (Example 52)	Mandatory	High
GTAB-088	Group the time intervals into higher units and distinguish these with more prominent markings (Example 52)	Mandatory	Medium
GTAB-089	Do not display tick marks for every possible time interval. Do not mark unconventional time intervals, such as every six minutes (Example 53) Tick marks should be used to allow the viewer to estimate the time of the observation by seeing where the point lies in relation to regularly spaced time intervals. The tick marks should be based upon meaningful time intervals, such as every hour or every day, depending upon the timescale	Mandatory	Medium
GTAB-090	Ensure that the time interval markings are always visible when graph data is being displayed	Mandatory	High

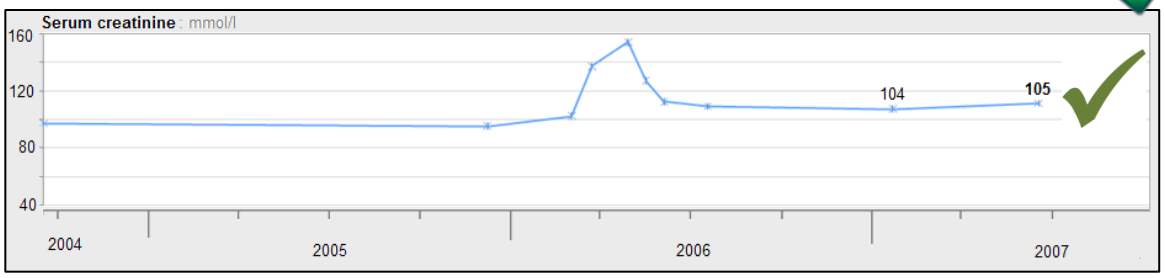
Usage Examples

Example 50: Do not display time non-proportionally



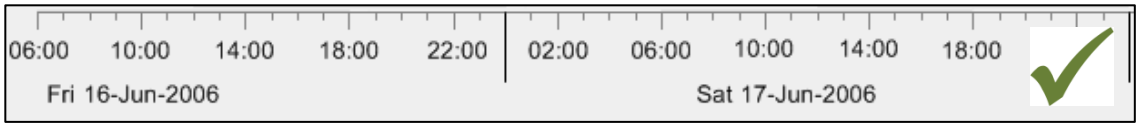
The example above shows data displayed according to a non-proportional timescale. This pattern may be misleading, given the large differences in time between readings.

Example 51: Display time with a proportional axis

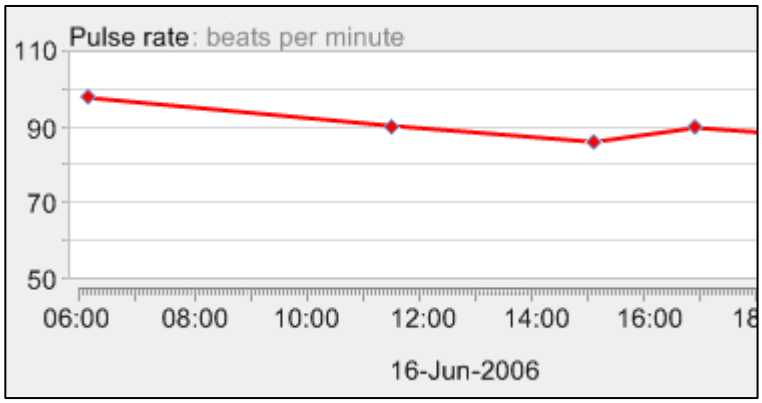


Data should be displayed according to a proportional timescale. That is, the distance along the x-axis increases proportionally with the time it is representing. For example, in one scale, one hour may be represented by 10mm (running from left to right).

Example 52: Feature markings that group time intervals



Example 53: Do not use too many ticks



Units of time should be marked on the axis so that the clinician can calculate where in time a given data point lies. These tick marks are useful to give the clinician a general idea of the time and are not necessarily intended to give a precise time. As such, they do not need to comprise all the time gradations. There is a limit to how many tick marks can be labelled and providing too many ticks can unnecessarily distract from the important information on the graph. Accurate time values can be better accessed using other mechanisms (such as a focus line) whereas tick marks should be used simply to reflect major time gradations. These should be dependent upon the timescale that is being shown: the smaller the timeframe, the more granular the major time gradations.

Rationale

The CUI research programme **{R5}** compared graphs with proportionally-spaced time intervals with those having non-proportionally-spaced time intervals. The findings were that clinicians were concerned that non-proportional time intervals could be misinterpreted and therefore dangerous. This finding is in spite of the fact that many paper charts feature non-proportional time intervals. We believe that there is an expectation that electronic graphing is proportional because, unlike paper, the plasticity of electronic interfaces allows easy construction of proportional time intervals.

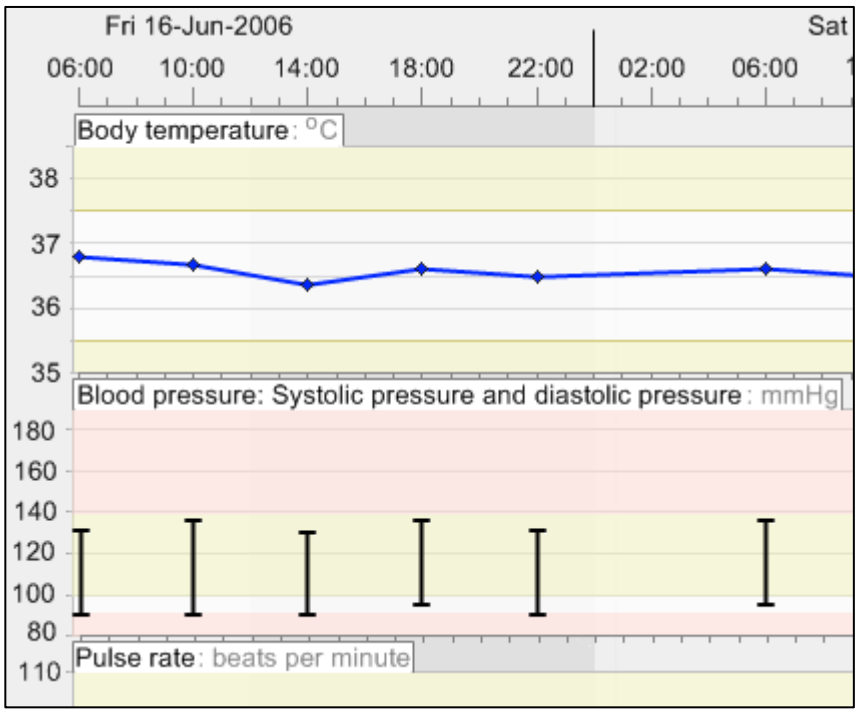
There is a risk that clinicians will see a non-proportional graph and will interpret the data patterns as if they were displayed according to a proportional timescale. In these situations, there could be the risk of missing important critical findings or of over-estimating rises or falls in data, both of which carry the possibility of harm to the patient.

4.3 Guidelines – Clinical Measure Axis Intervals

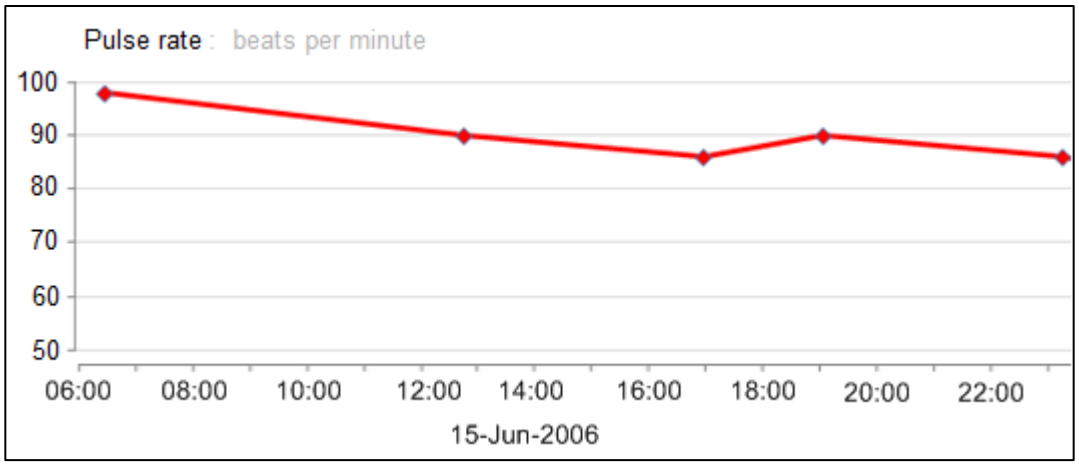
ID	Description	Conformance	Evidence Rating
GTAB-091	Feature markings for non-time variables along the (vertical) y-axis (Example 54)	Mandatory	High
GTAB-092	Where possible, feature y-axis markings according to decimal intervals or intervals that are simple to add up (Example 55) Decimal intervals are such as 10s or 20s. Intervals that are simple to add up are such as 1s, 2s, 5s, 0.1s, 0.2s or 0.5s	Recommended	High
GTAB-093	When marking the y-axis, mark numbers for which it is easy to compute the mid-points (Example 57) For example, with intervals marked at 20 units, it is easier to mentally compute the midpoint between 110 and 130 than it is to compute the midpoint between 115 and 135	Recommended	Medium
GTAB-094	Do not mark arbitrary intervals in an attempt to feature a fixed number of gradations (Example 56)	Recommended	High
GTAB-095	Where appropriate, group the data intervals into higher units and distinguish these with more prominent markings	Recommended	Medium

Usage Examples

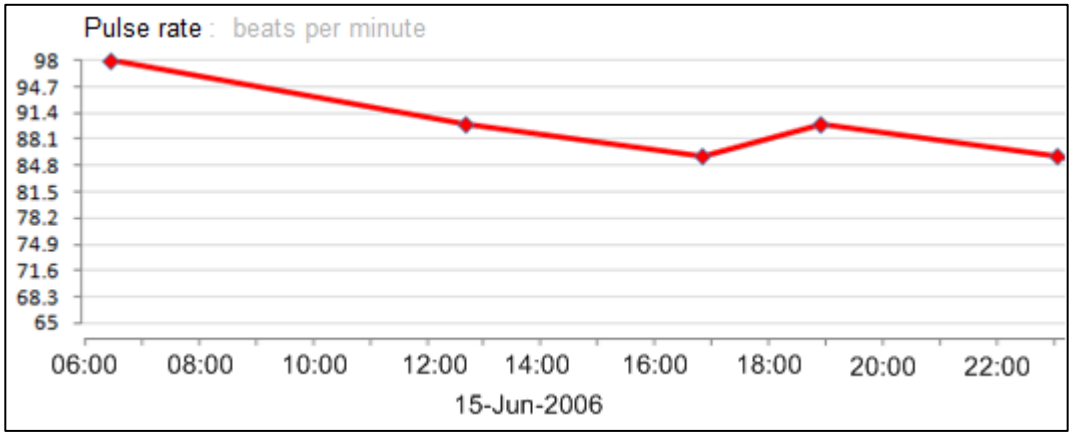
Example 54: Feature markings along the vertical y-axis



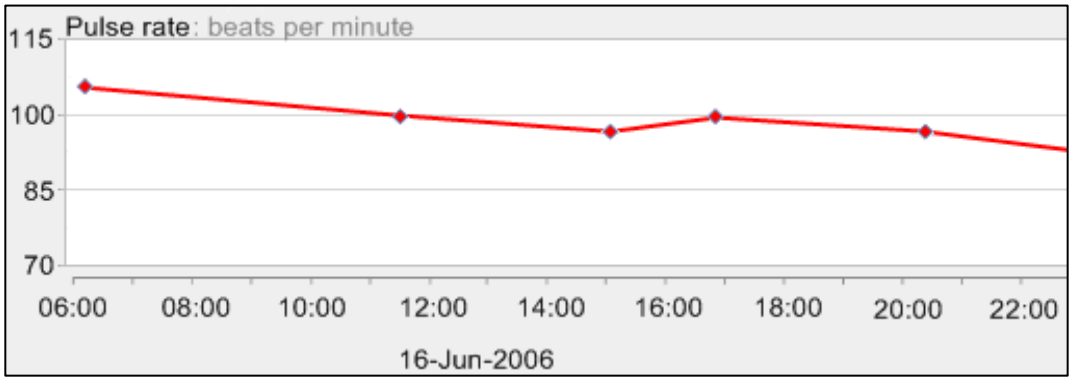
Example 55: Feature decimal intervals on the y-axis



Example 56: Avoid poorly chosen intervals on the y-axis which create artificial and incorrect precision



Example 57: Do not use intervals in multiples of 15 as it makes it difficult for people to mentally compute the mid-point



Rationale

As it is often impossible to clearly mark and label all data gradations on an axis, the design will need to rely on the user being able to mentally compute the difference between the marked axes.

Studies have shown that users find it easier to read from axes that are marked in 10s and 2s than other multiples. This was reported by Wyatt and Wright **{R11}**, citing work by Chapanis {**R21**} This can be extended to 5s (half of 10) and 1s. People find it easier to calculate the midpoints between intervals based on these multiples and therefore they are much more helpful than intervals based on other intervals (for example, 15 or 7). Experts **{R11, R21}** in data visualisation also suggest that people generally find it easier to calculate the difference between interval markings when these are for even rather than odd numbers.

The grouping of axis intervals into higher level 'chunks' is also recognised best practice for displaying graph axes **{R8}**.

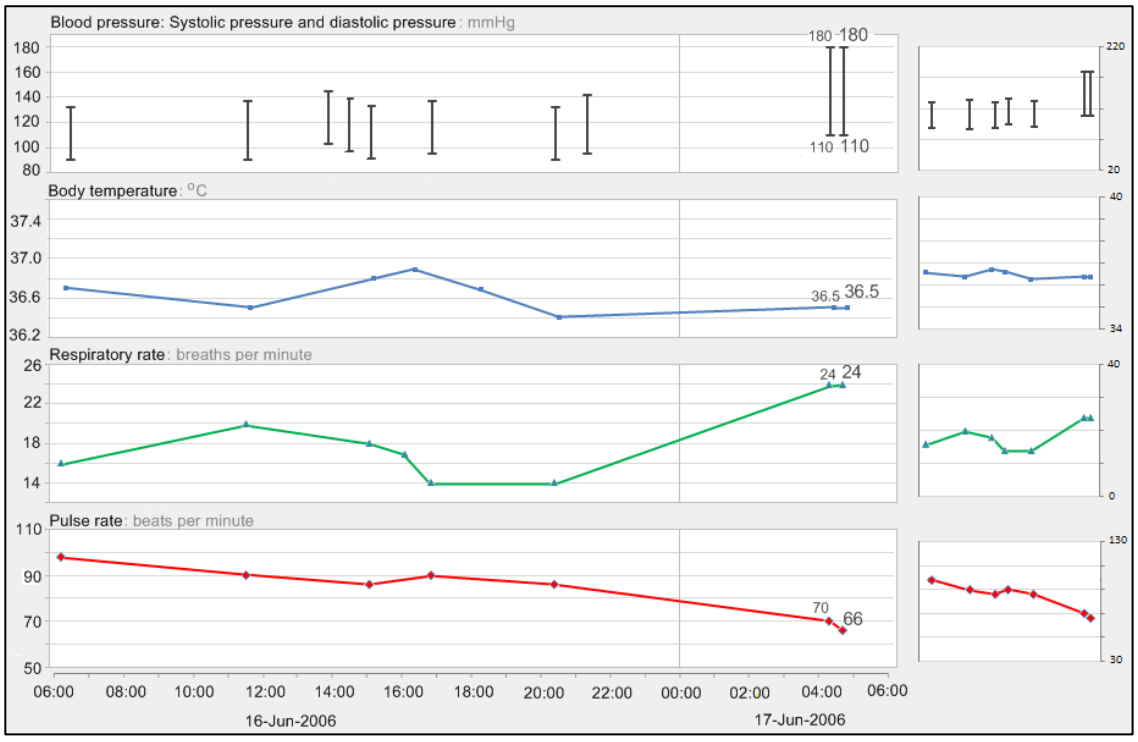
4.4 Guidelines – Axis Ranges

ID	Description	Conformance	Evidence Rating
GTAB-096	By default, the x-axis should be constrained to one of a set of defined time ranges For example, 24 hour, 2 week, 2 year and so on	Recommended	Medium
GTAB-097	As new data points are added to a graph, do not change the time scaling. If adding the new data point means that the current data exceeds the time range, shift the time window to include the new data rather than increasing the time range in size (Example 58)	Recommended	Low
GTAB-098	Do not show all data by default, unless there is a specific clinical reason for doing so For example, if the patient's record holds data going back five years, do not force the user to view all this data before choosing the specific range they require	Mandatory	Low
GTAB-099	If all data must be shown by default, the data should be shown within the nearest set timescale within which all the data to be displayed can be shown	Recommended	Low
GTAB-100	Y-axis ranges do not need to start from zero (Example 59)	Mandatory	High

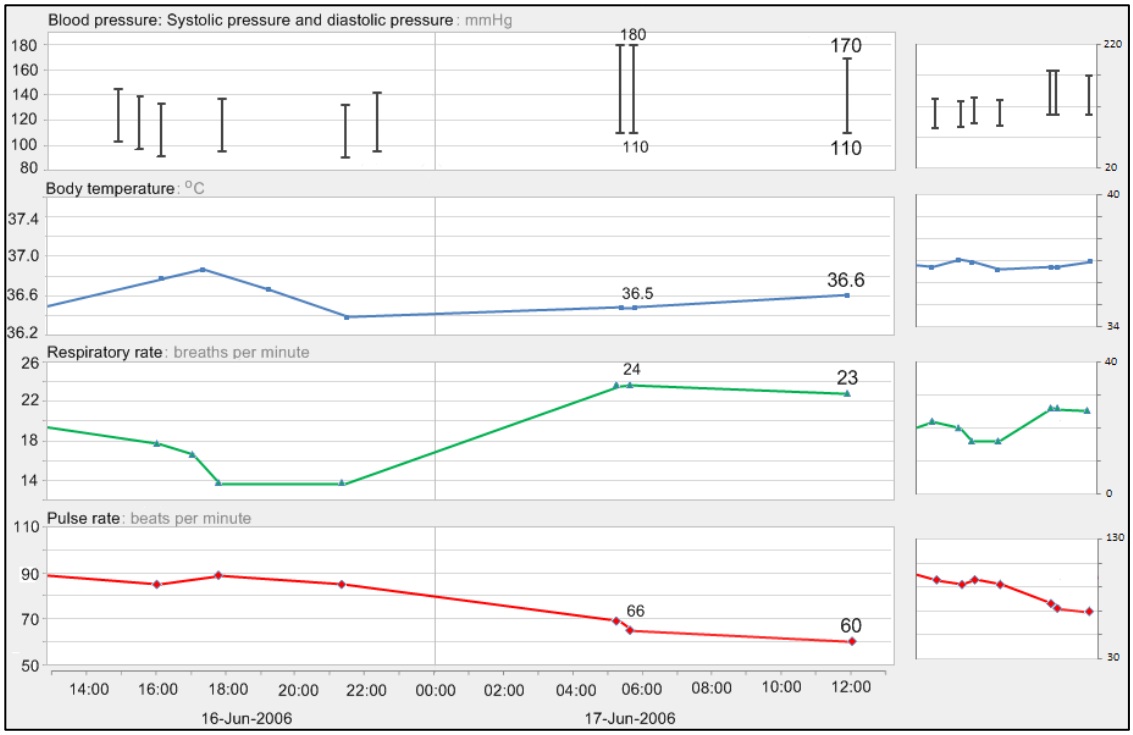
Usage Examples

Example 58: Shift the time range forward when data is added

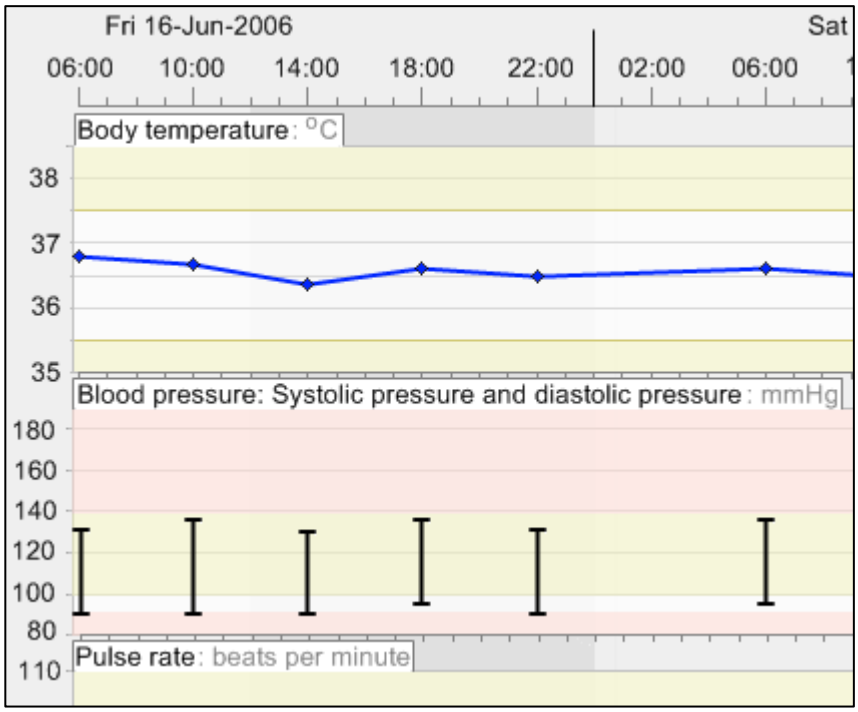
Step 1: This is the view at 06:00 (the last data entry was at 04:45)



Step 2: This is the view at 13:00 (the last data entry was at 12:30). The window has shifted to show the new data but kept the same timeframe



Example 59: The axis may start from numbers other than zero



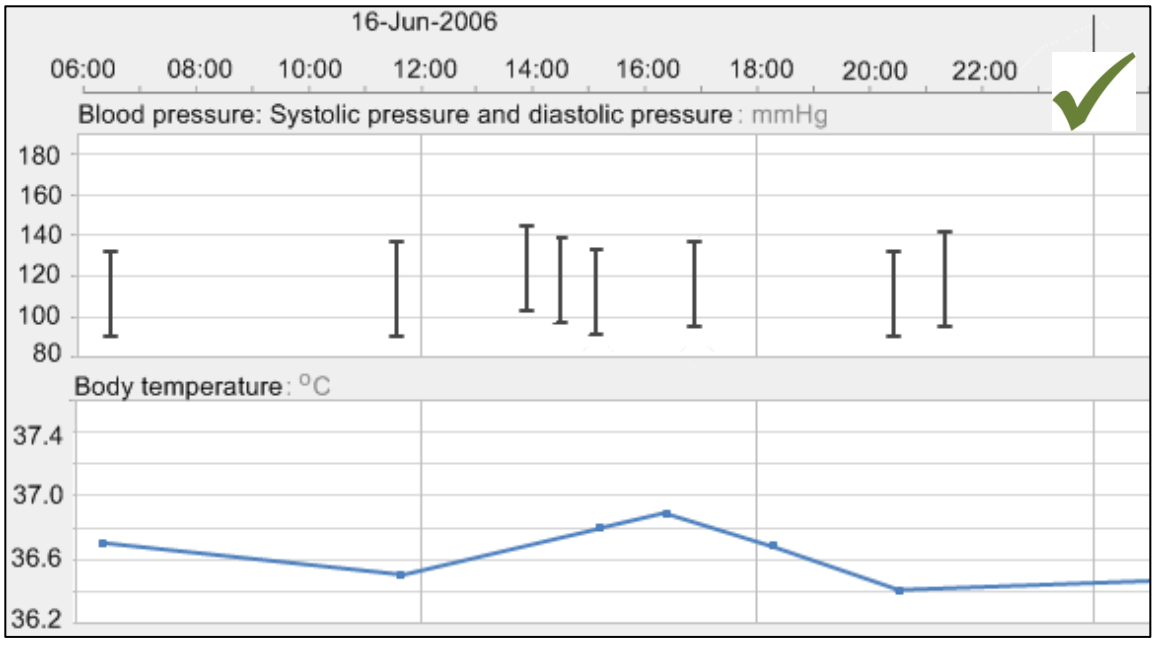
Rationale
In order to achieve consistent scaling, we recommend the use of a default set of fixed timescales to display data. In addition to providing sufficient time-range labelling, this should provide the user with sufficient orientation to be able to correctly interpret the data pattern. In many situations, a clinician will regularly view data at one or two given timescales, depending upon their discipline. For example, in acute care, clinicians may view data according to a 24 hour timeframe with intervals set hourly or they may view four hourly readings at a longer timeframe (perhaps 48 hours or three-days). It makes sense to ensure that these timeframes are set as the default standard views in these instances. Presenting the data in a 21 hour timeframe would require more thinking on the part of the clinician and could result in errors if 24 hours is expected. This would not preclude the clinician being able to adjust the time window to better fit their current clinical situation, but they would have to view one of the standard timeframes first. We have discussed this notion with clinicians and leading clinical data visualisation experts who agree that ensuring the use of default timeframes and scales would be necessary to ensure that the data is displayed sufficiently consistently. CUI user research showed that, overall, clinicians indicated that they did not need the axes to always begin at zero **{R5}**. They also recognised that forcing graphs to show the zero values means that the necessary scaling can hide important changes in the data.

4.5 Guidelines – Gridlines

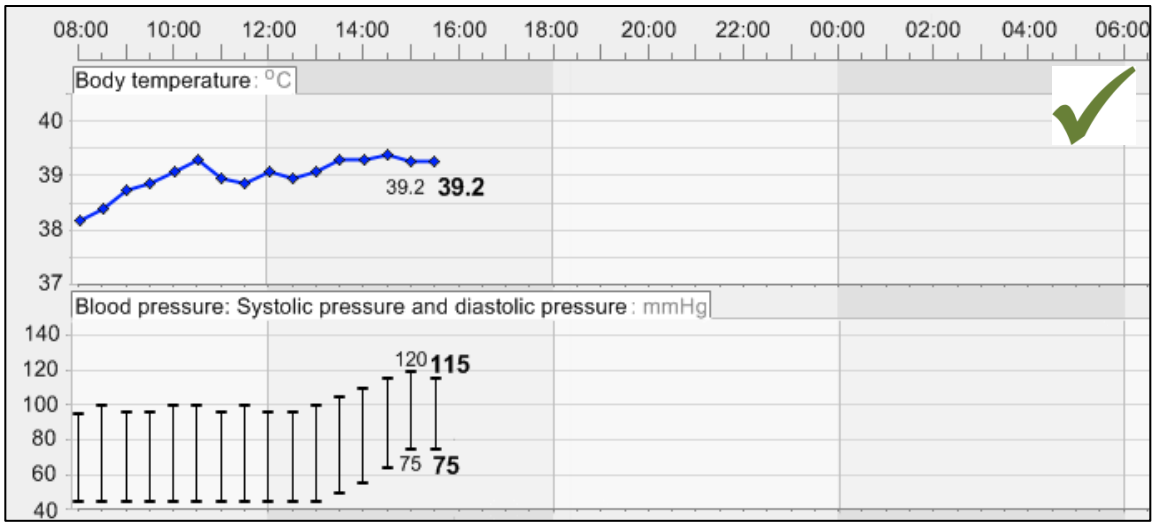
ID	Description	Conformance	Evidence Rating
GTAB-101	Feature horizontal gridlines for major gradations on the y-axis For example, every 20 mmHg, or every 0.5° C	Recommended	High
GTAB-102	Ensure that, in the default view of data, horizontal gridlines are featured consistently for each data series	Mandatory	High
GTAB-103	Use gridlines sparingly. Do not feature gridlines for every possible gradation (Example 62)	Mandatory	High
GTAB-104	Feature vertical gridlines for major gradations on the x-axis (Example 60) For example, every 6 hours for a 24 hour view or per day for a three-day timeframe	Recommended	Low
GTAB-105	Ensure that vertical gridlines are featured consistently for each time range window (Example 60)	Mandatory	Low
GTAB-106	Use the same vertical gridlines for all graphs in view at the same time (Example 60)	Recommended	Low
GTAB-107	Offer users the option of (temporarily) switching off the gridlines	Recommended	Medium

Usage Examples

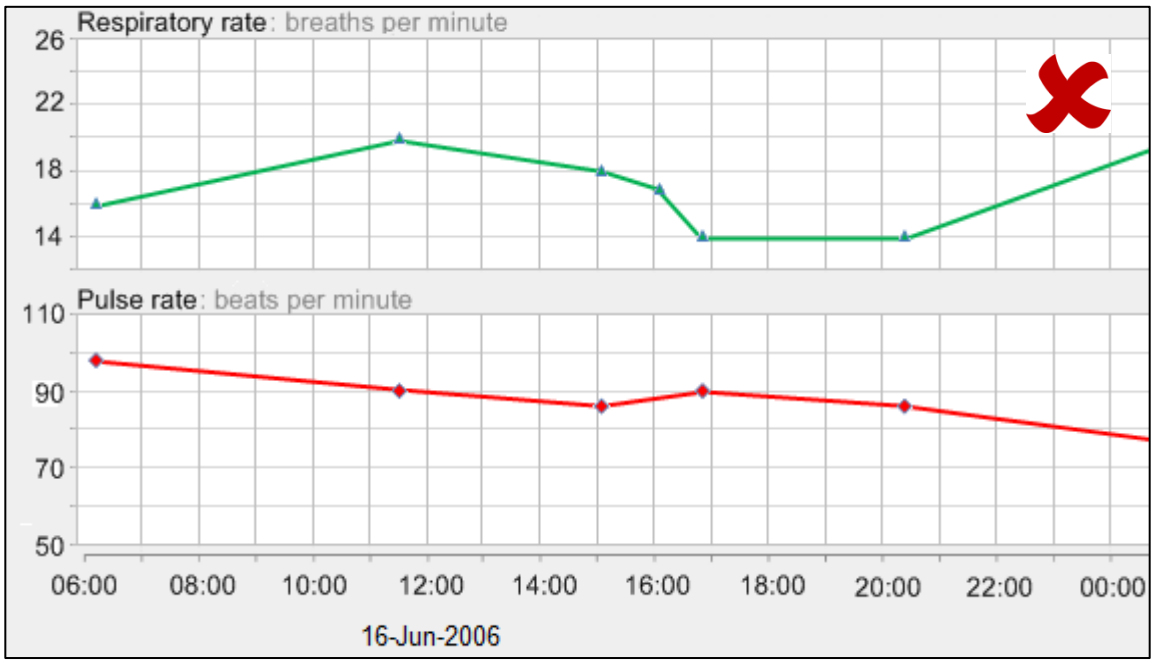
Example 60: Feature regular gridlines for major gradations



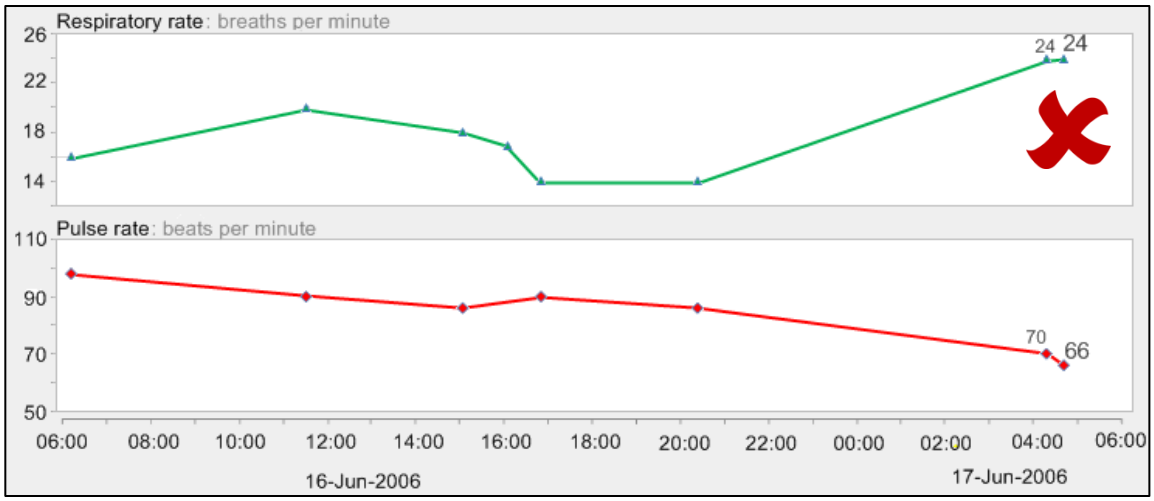
Example 61: Feature shading at regular intervals along the time axis



Example 62: Do not display too many vertical lines



Example 63: Do not switch off gridlines in the default view



Rationale

The CUI research team have elicited clinicians' responses to differing levels of gridlines and have found that clinicians prefer regular horizontal lines **{R5}**.

It is accepted best practice to feature some horizontal lines **{R8}**, although these should be kept to a minimum **{R9}**. Some authors suggest that horizontal lines are superfluous to clinicians' perception of graphical patterns. However, to help clinicians estimate data values fairly accurately, horizontal gridlines are useful. Given the 'letterbox' shape of the graphs, horizontal lines tend to be more important than vertical lines. However, clinicians have suggested that some vertical lines could be useful (for example, indicating the divide between days).

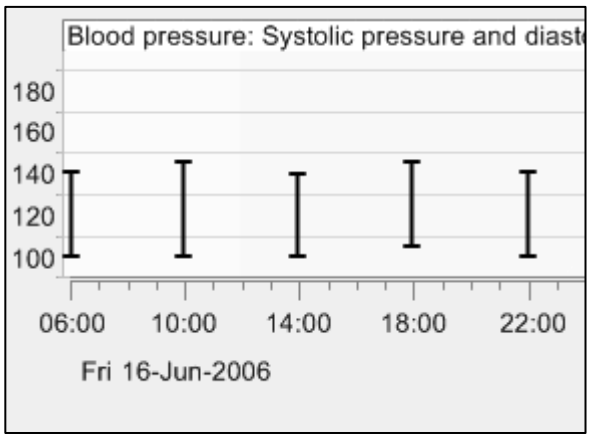
Too many vertical lines can be a problem. In usability testing, some clinicians mistakenly thought that the intersection between vertical lines and the data interpolation line indicated data points, as this is essentially what happens in paper charts (namely, that there is a vertical line for each reading **{R6}**).

4.6 Guidelines – Axis Labels

ID	Description	Conformance	Evidence Rating
GTAB-108	Label the y-axis markings, not the spaces between them (Example 64, Example 65) An exception is where readings are expressed as ranges (though this does not apply to the vital signs observation data)	Mandatory	Medium
GTAB-109	Label the x-axis markings, not the spaces between them (Example 66) An exception is when times are expressed as ranges, rather than specific points in time. For example, a day or a month may be shown in the gap, with the assumption that the axis marks represent 00:00 (that is, the technical dividing point between days)	Recommended	Medium
GTAB-110	Avoid diagonally oriented label text unless additional grids are added to mitigate the risk of users associating a label with the wrong marking	Mandatory	Low
GTAB-111	Avoid vertically oriented label text (for both the x-axis and the y-axis)	Mandatory	Medium
GTAB-112	On the x-axis, ensure that the full dates are always communicated This could be done by hierarchically labelling year, then month, then date	Mandatory	Medium
GTAB-113	If possible, communicate days of the week in the x-axis labelling (Example 68)	Recommended	Low
GTAB-114	Provide labelling of the time-range (Example 69) For example, 'Last 24 hours', '15-Jun-06 to 17-Jun-06', '12 hours from Admission'	Recommended	Low

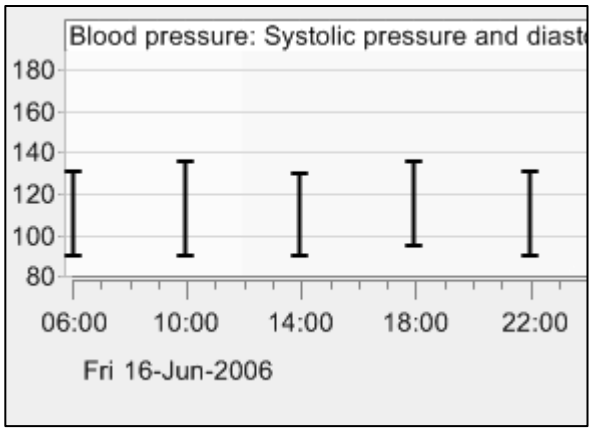
Usage Examples

Example 64: Avoid positioning the Y-axis labels in the gaps rather than aligned with the ticks



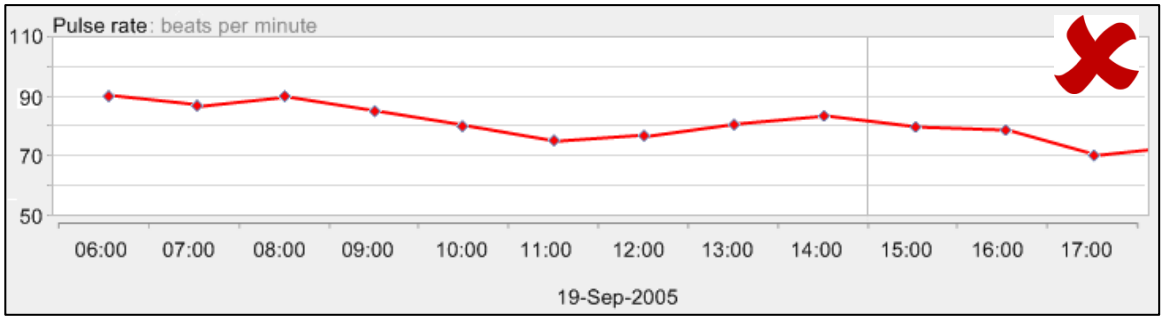
In this example, the Y-axis labels are displayed against the gaps between ticks, not aligned with the ticks (on the left-hand side). This leaves a lot of ambiguity in the interpretation of the data. For example, is the first diastolic reading 100, 80 or 110 mmHg?

Example 65: Align the Y-axis labels with the ticks

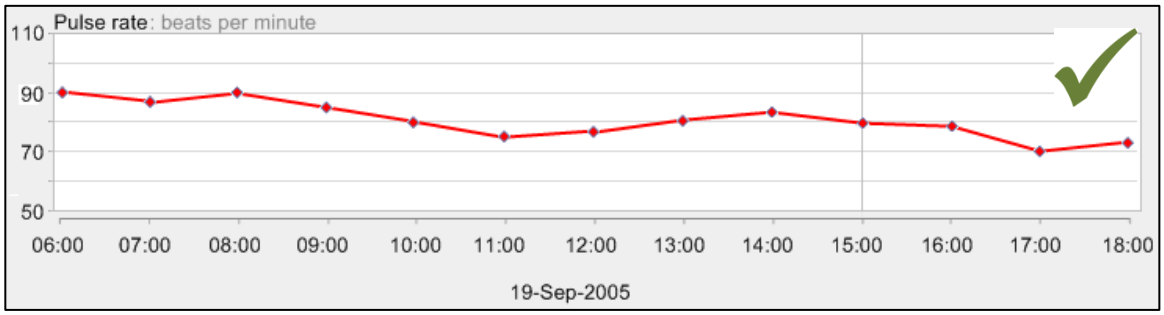


In this correct example, the values to which the labels correspond is clear: the first diastolic reading is 90 mmHg.

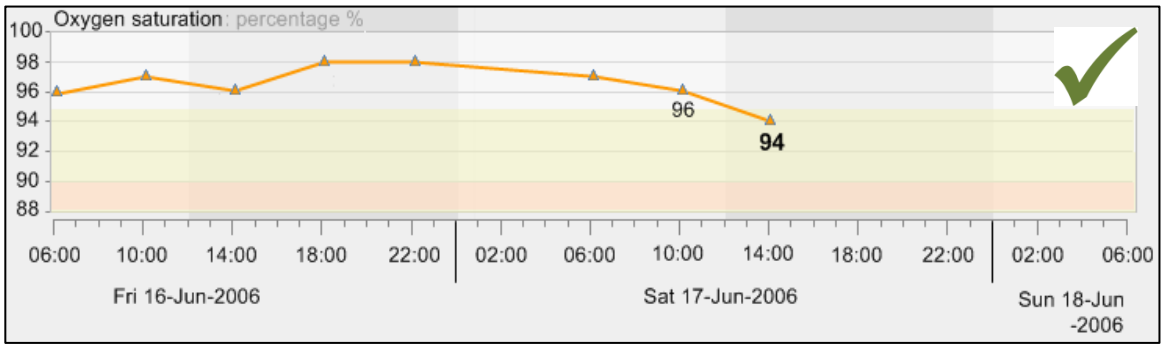
Example 66: Do not show the x-axis with times in the gaps not on the marks



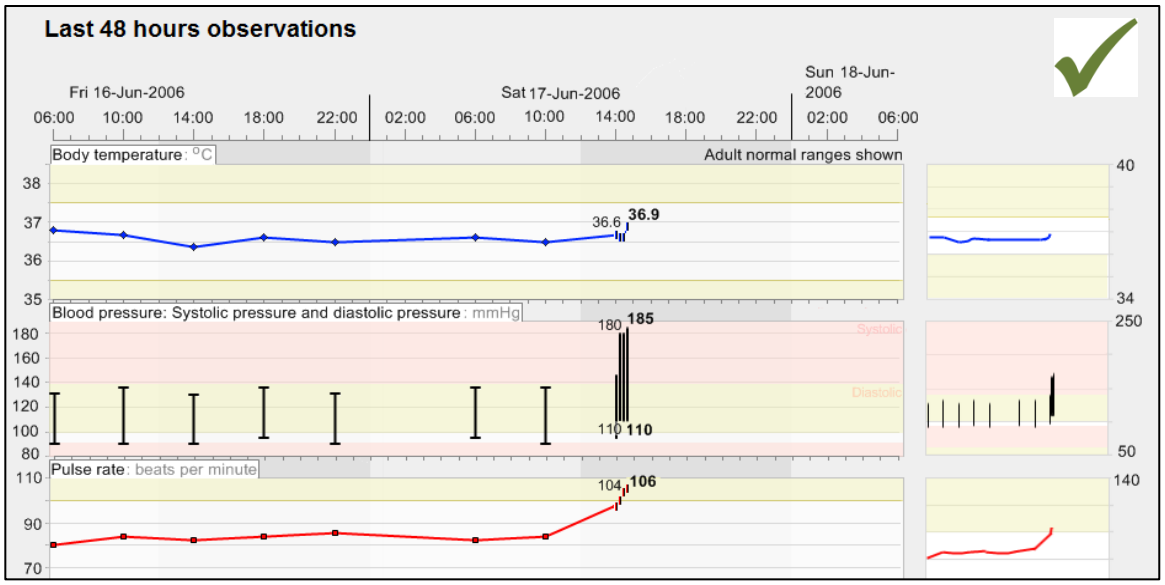
Example 67: Show the x-axis with times shown on the marks, not in the gaps



Example 68: Show the days of the week along with the date, where it is clinically relevant



Example 69: Display a summary of the information shown (such as, 'Last 48 hours observations')



Rationale

Labelling of both x and y axes must be clear and easy to read. Misreading of labels can cause misinterpretation of data and therefore lead to poor decisions over a patient's health.

In current paper charts, the axis labels are often aligned against the gaps rather than the ticks in the axis. This means that there could be room for misinterpretation. However, the clinician will often write in the actual number in text next to the data point symbol in order that the data points cannot be misinterpreted. It is clearly better to avoid the potential for such ambiguity.

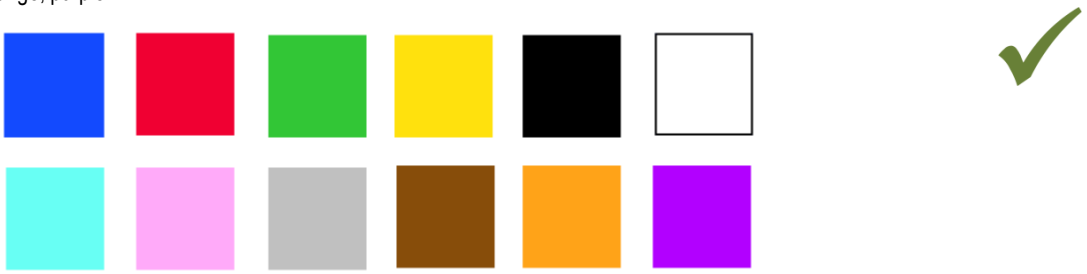
5 Layout, Density and Formatting Guidance Details

5.1 Guidelines – Colours and Contrasts

ID	Description	Conformance	Evidence Rating
GTAB-115	Display data points in high saturation colours except in those situations where the system needs to distinguish one data series over others (Example 70, Example 72)	Recommended	High
GTAB-116	The colours of the data series should be approximately equal in terms of saturation except where one data series is being emphasised over the others	Mandatory	High
GTAB-117	Where one data series is required to stand out against the other data series, the others can be displayed in lower saturated versions of the same hues	Recommended	Low
GTAB-118	Where special low-light formatting is **not** required (that is, where the environment in which the data is to be viewed is well-lit), background colour for the graph area should be white or off-white	Mandatory	High
GTAB-119	The surrounding background for the graphs should be a neutral low-saturation colour (Example 72)	Recommended	High
GTAB-120	Ensure a good contrast between the background colour and the foreground colours (Example 72) The foreground colours are for the data points, interpolation lines and copy including labels and headers	Mandatory	High
GTAB-121	Provide a black border for data points. Reverse to a white border in the event of the colour of the data point being reversed (Example 73)	Recommended	High
GTAB-122	Where special reverse formatting is required, ensure a good reverse contrast	Mandatory	Medium
GTAB-123	Use only a few colours to ensure they are distinct. Using up to twelve colours is acceptable, but do not use more. Only use one of each colour category (Example 70) Base the colours upon the Berlin and Kay colour categorisation of red, green, yellow, blue, black, white, pink, gray, orange, brown and purple. Plus cyan may be added to complete the twelve	Recommended	Medium
GTAB-124	The first colours to be selected should be blue, red, and yellow, unless there is a background colour that conflicts with any of these	Recommended	Low

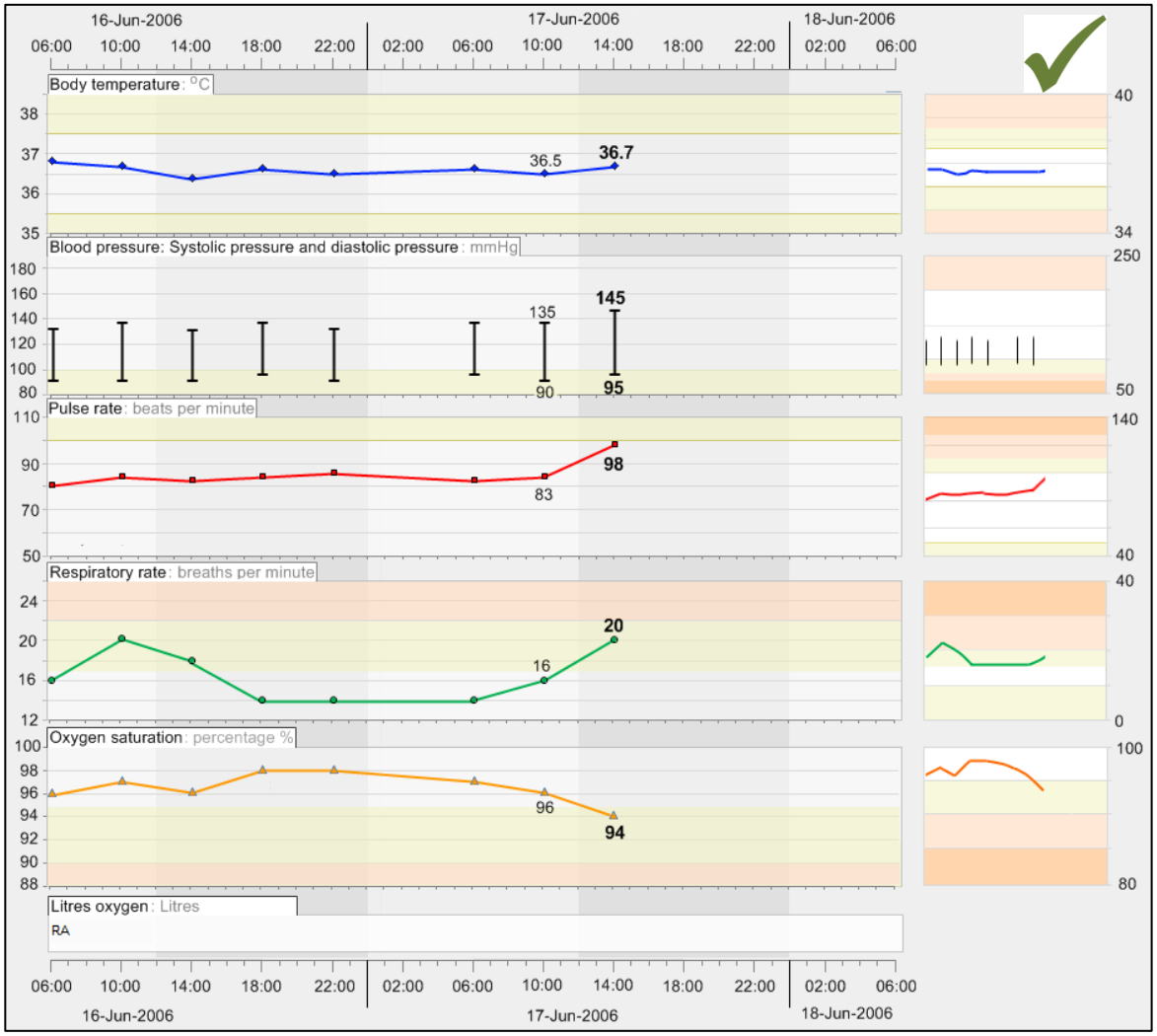
Usage Examples

Example 70: Twelve distinct saturated colours for data points: blue, red, green, yellow, black, white, cyan, pink, grey, brown, orange, purple



Example 71: Twelve good unsaturated colours for when one data series (or single data point) needs to stand out against the rest

Example 72: Feature saturated primary colours as the foreground colour, except where there could be a conflict



Note

In the example of the oxygen saturations above, the colour yellow has been rejected in favour of a dark orange because of the potential conflict with the background colour.

Example 73: Feature black borders for the data points

Rationale

Well saturated colours are easier to detect and are suited for small colour-coded objects **{R7}** and contrast well against an unsaturated background. This means that the data will be easier to see at a glance and leaves less scope for misinterpretation.

Regarding the choice of colour, a seminal study in the late 1960s by Berlin and Kay **{R22}** revealed a colour categorisation that transcends cultural boundaries. This indicated eleven colour labels: red, green, yellow, blue, black, white, pink, gray, orange, brown and purple. To these has been added the colour 'cyan' by leading perceptual psychologist, Colin Ware **{R7}**. It is recommended therefore that the graphs should not feature more than one of any of these colour types (for example, do not distinguish data with two shades of red or multiple shades of grey).

The relevant BSI standard **{R2}** indicates that: 'If colour coding is used to distinguish related pieces of information, no one colour should be too prominent or too retiring'.

Providing a thin black border for data symbols is important as colours appear differently according to their contrast against the background colour. Contrast errors have been shown to be reduced with borders around the coloured areas or by using a low saturation, relatively uniform background.

According to psychological literature, red, green, blue and yellow are 'hard-wired' into the brain as primary colours. These codings are easier to remember and should be considered first in any colour coding. However, given the problems that colour-blind people have with green and red, the colour should not be the only coding mechanism: also use shape, location and labelling to distinguish data series.

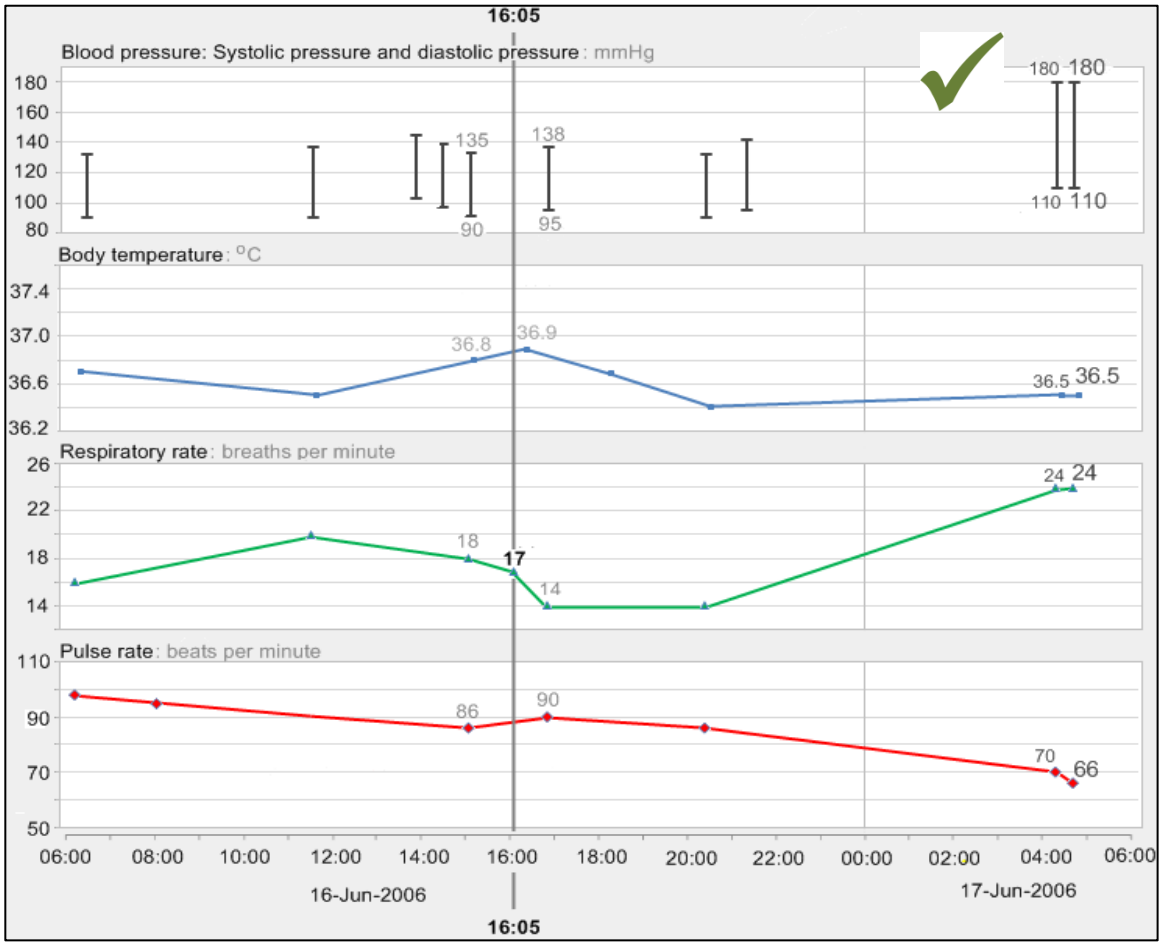
If displaying a dark background with a light foreground, as for light solutions, avoid locating red text and dark blue text adjacent to one another on a black background. This can create the illusion of one colour appearing closer than the other (most people see the red as appearing closer than the blue). The illusion is called 'chromostereopsis' and should be avoided **{R7}**.

5.2 Guidelines – Typeface Formatting

ID	Description	Conformance	Evidence Rating
GTAB-125	Copy must be displayed in a sufficiently dark colour to contrast against the background For example, make the copy dark grey or black. The minimum contrast between text and its background must be 3:1, with a preferred ratio of 10:1	Mandatory	High
GTAB-126	Feature a font size of between 2 mm and 6 mm for the x-height of the letter (Example 74) That is, the height of a letter 'x is between 2 mm and 6 mm'	Mandatory	High
GTAB-127	Avoid visually elaborate typefaces (Example 75)	Mandatory	Low
GTAB-128	Use a typeface or font family where the number 1 is clearly discernable from the lowercase letter 'l' or a capital letter 'J'	Mandatory	Low
GTAB-129	Ensure that each kind of screen copy is displayed in a consistent typeface, size, colour and weight For example, all y-axis labels should be displayed in the same format Exceptions include instances where a label needs to stand out against other labels of the same kind (such as when a data value is in focus). For example, the most recent data value must be more prominent than the preceding values and this can be achieved with its formatting	Recommended	Medium
GTAB-130	Avoid underlines	Recommended	Medium
GTAB-131	Avoid coloured text highlights	Recommended	Medium
GTAB-132	Avoid animated or flashing text	Mandatory	High
GTAB-133	Do not feature text written vertically (Example 76)	Mandatory	Medium
GTAB-134	Avoid the use of brackets (either round or square) in the numerical value labels	Mandatory	High

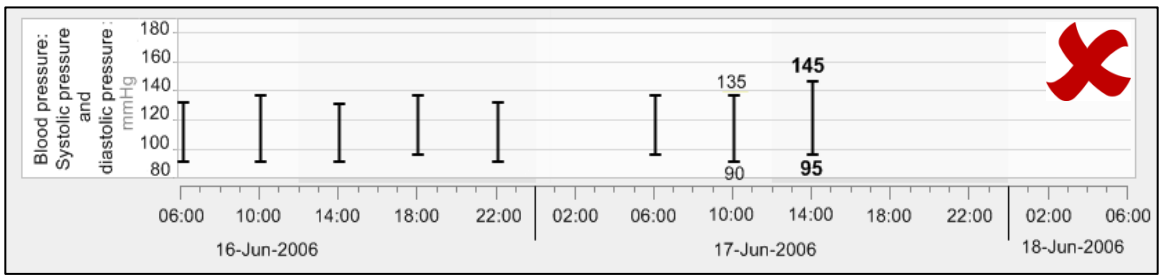
Usage Examples

Example 74: Feature reasonably sized text



Example 75: Avoid elaborate decorative font

Example 76: Do not display text written vertically (left hand side)



Rationale
Text is a key component in the communication of the data. It should clearly identify the different data sets and provide reference labels for the axes. But it must also allow the user to view the data to a level of precision that is not possible with a purely graphical display. To this end, the text must be kept simple and without elaboration, large enough to view and consistently sized. By these means, it avoids unintentionally communicating an effect in the data where one does not actually exist. Text should follow recognised standards for its display (such as the International Standards Organization (ISO) standard 9241 **{R17}** and the World Wide Web Consortium (W3C) Web Accessibility Initiative (WAI) guidelines)[3]. However, it is also important to ensure that the text is not so prominent that it detracts from or obscures the graphic data that is the most important element of communication. Text should not add too much superfluous and distracting 'non-data ink' **{R24}**. Underlines constitute an instance of unnecessary 'non-data ink' and, given that the main data comprises points connected by lines, an additional line distracts from the main communication. Also avoid brackets as they can be confused with the number '1'.

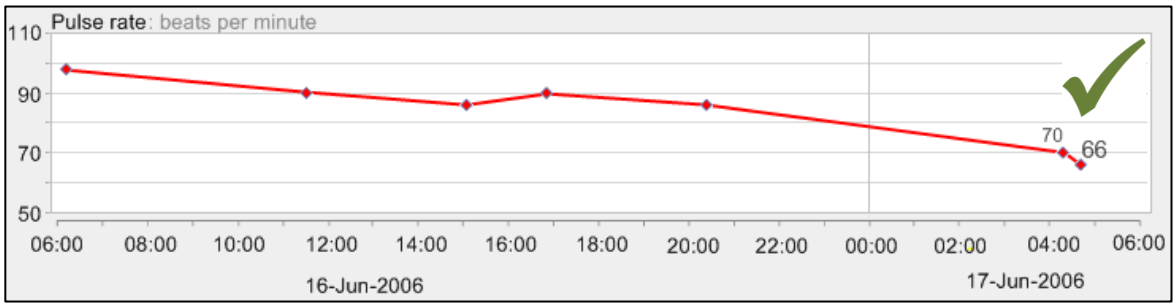
[3] World Wide Web Consortium (W3C) Web Accessibility Initiative (WAI) guidelines **{R23}**:http://www.w3.org/WAI/

5.3 Guidelines – Line Formatting

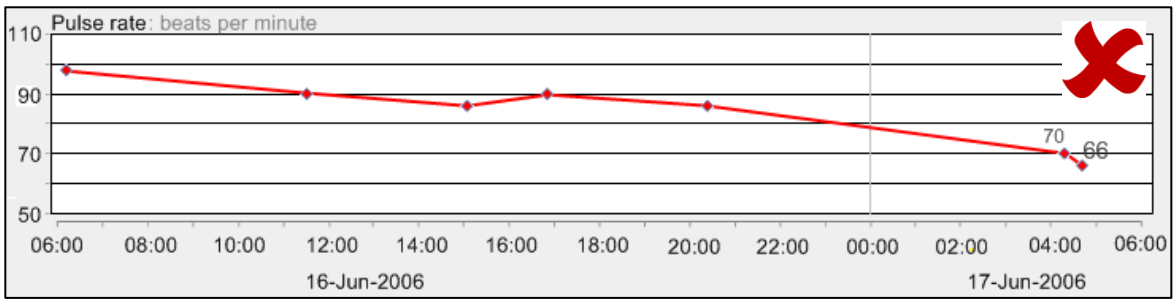
ID	Description	Conformance	Evidence Rating
GTAB-135	Format gridlines in a light grey colour (Example 77)	Recommended	Medium
GTAB-136	Format gridlines in a light weight (Example 77)	Mandatory	Medium
GTAB-137	Make gridlines lighter in weight and colour saturation than the data points and the interpolation lines (Example 77)	Mandatory	Medium
GTAB-138	Format axis lines in a light grey colour (Example 77)	Recommended	Medium
GTAB-139	Format axis lines in a light or medium weight (Example 77)	Recommended	Medium
GTAB-140	Distinguish major axis marks from minor axis marks by weight and/or length	Recommended	Medium

Usage Examples

Example 77: Format light grey gridlines



Example 78: Do not format heavy gridlines



Rationale

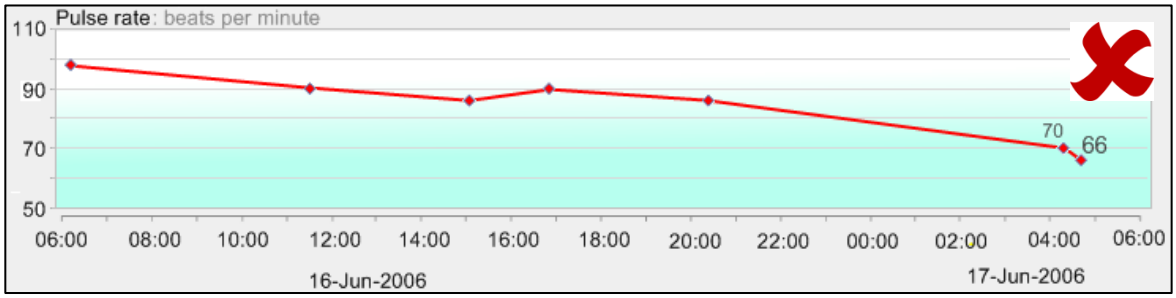
Featuring some gridlines is recognised best practice for graphs **{R8}**. However, some leading authors argue against overuse of gridlines and caution against the use of heavy weight lines as these can interfere with the viewer's perception and interpretation of the actual data **{R9}**.

5.4 Guidelines – Other Formatting Considerations

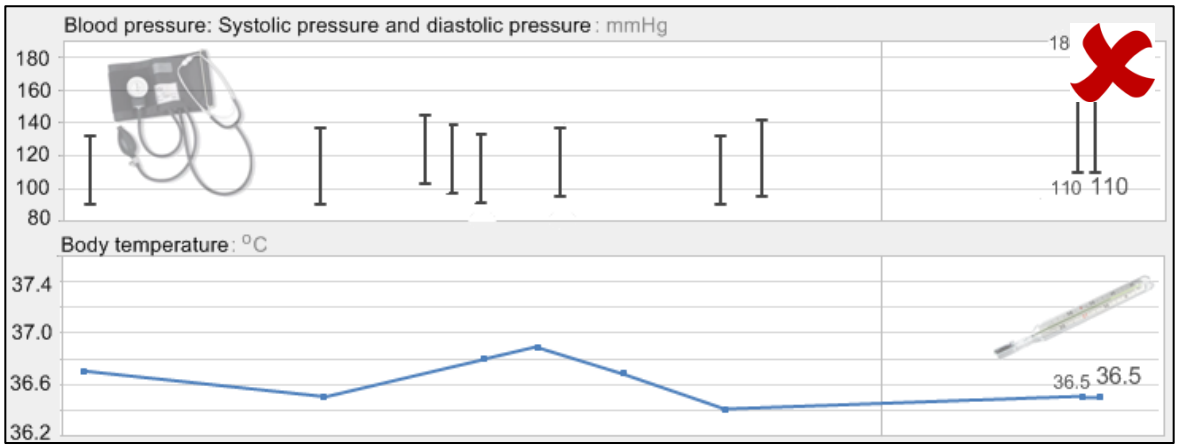
ID	Description	Conformance	Evidence Rating
GTAB-141	Do not feature watermarks or background images on the graph area	Mandatory	Medium
GTAB-142	Feature solid colours and avoid patterned colours for both background and foreground objects (Example 79)	Recommended	Medium
GTAB-143	Avoid any non-functional graphical elaboration that is not actual data or a feature that directly supports the interpretation of the data (Example 80) Features that directly support the interpretation of the data include interpolation lines, axes, grids and focus	Recommended	Medium
GTAB-144	Do not force users to choose format styles each time they view the data	Recommended	Low

Usage Examples

Example 79: Do not feature a colour gradient background or other pattern



Example 80: Avoid unnecessary elaboration



Rationale

Text written on top of an image or watermark can be difficult to read, especially for users with reading difficulties (such as dyslexia) **{R16}**.

Patterns can be problematic as well. Some hatching, that is stripy or 'criss-crossed' patterns, can create an unintended perception of movement that makes the graph difficult to read as can colour gradients in the graph area **{R7, R8}**.

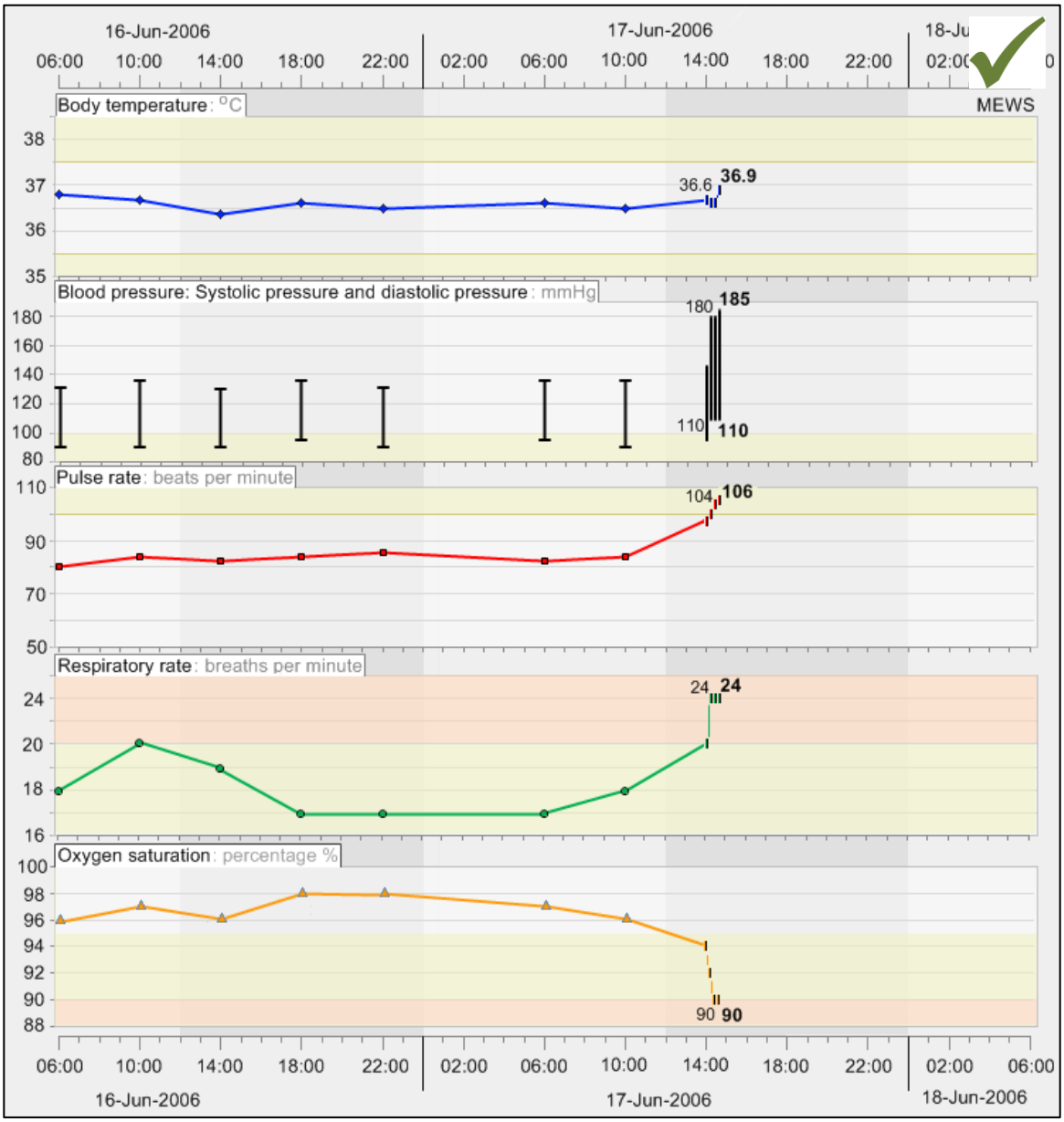
6 MULTIPLE DATA SERIES GUIDANCE DETAILS

6.1 Guidelines – Viewing Multiple Non-Overlaid Graphs

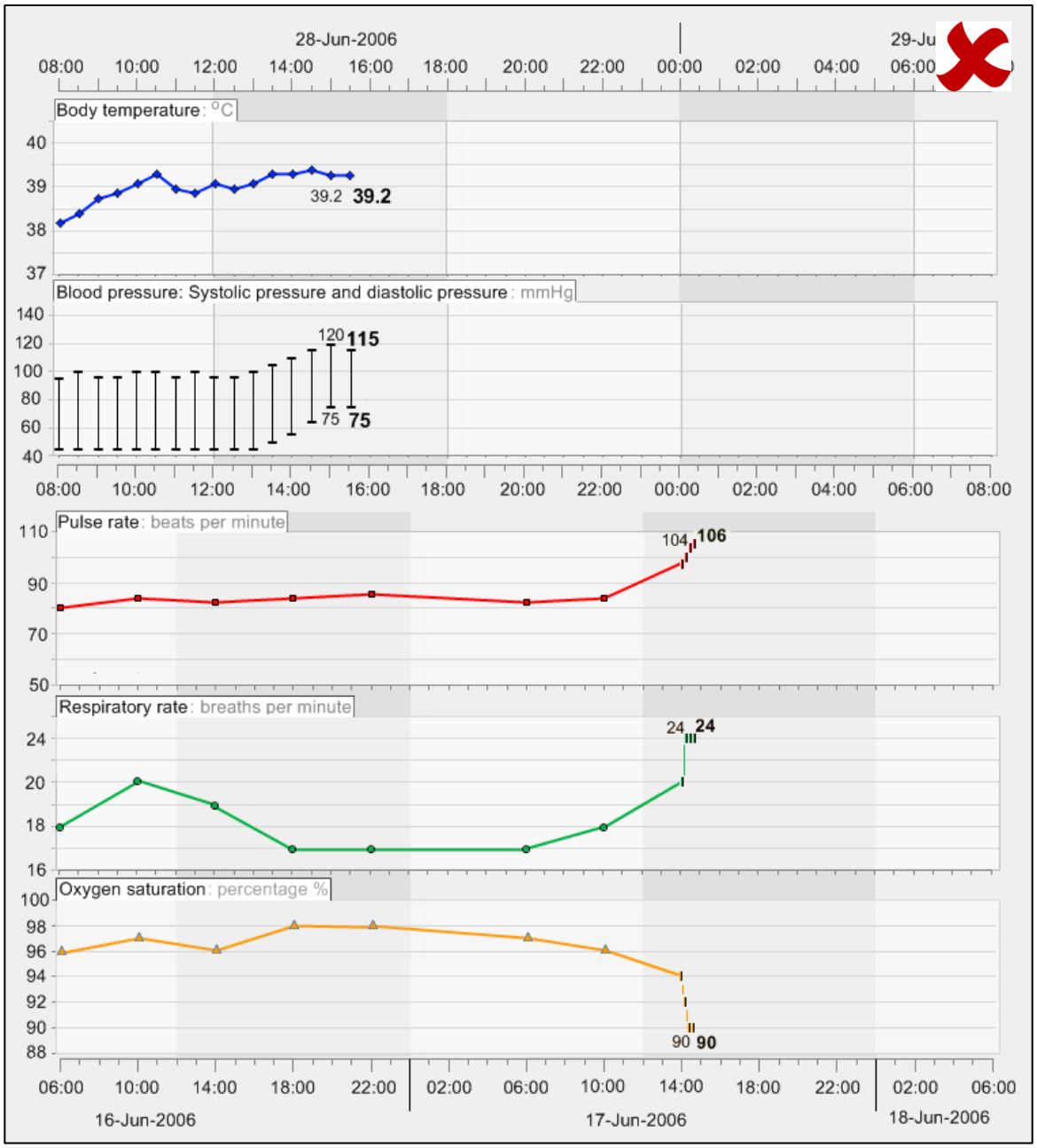
ID	Description	Conformance	Evidence Rating
GTAB-145	Display multiple data series vertically stacked unless there is clinical reason to do otherwise (Example 81)	Recommended	High
GTAB-146	Vertically align the left-hand axes of all the graphs (Example 81)	Mandatory	Medium
GTAB-147	Vertically align time intervals between data series that are being viewed simultaneously (Example 81, Example 82) There may be exceptions in the case of magnification, but further risk mitigation would be required that is out-of-scope for the current guidance.	Mandatory	High
GTAB-148	Minimise the space between graphs, though allowing for the inclusion of header labels (Example 81)	Recommended	High
GTAB-149	Where a convention exists, position sets of graphs in the appropriate order (Example 81) For example, position temperature at the top	Recommended	High
GTAB-150	Where no convention exists, the position of graphs in the vertical stacking can be determined by the order in which they are added to the view	Recommended	Medium
GTAB-151	The user should be able to change the order in which the graphs are stacked	Recommended	Low
GTAB-152	Where the number of graphs exceeds the vertical space available on screen, provide a suitable mechanism to move the viewing window up and down For example, using a scroll	Mandatory	Low
GTAB-153	Where there are graphs that have been chosen for viewing, but are not in view, feature a suitable mechanism to communicate that there are further graphs not in view	Mandatory	Low

Usage Examples

Example 81: Vertically stack graphs



Example 82: Do not display vertically stacked graphs at different timescales



Rationale

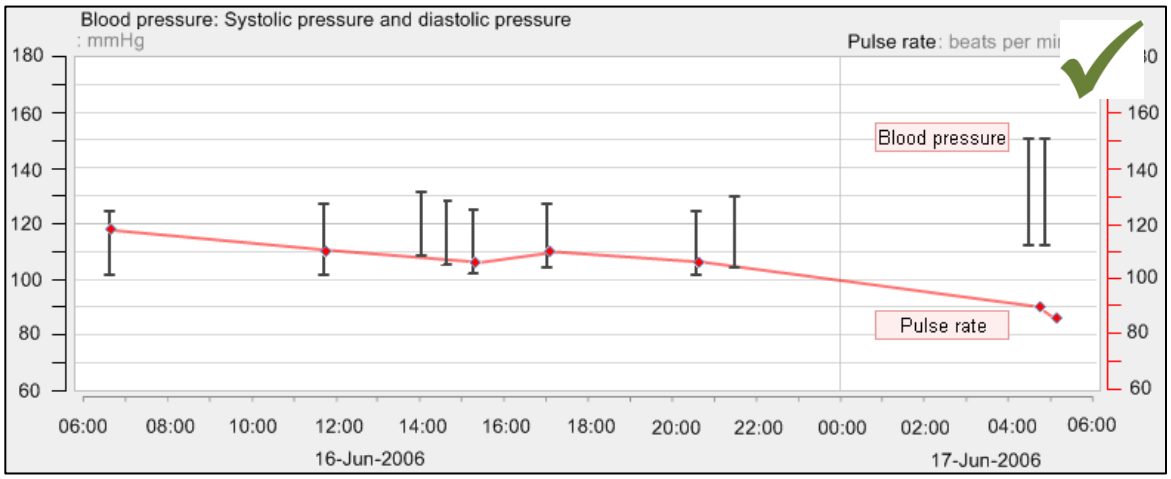
CUI research showed that clinicians expected blood pressure data to be located next to pulse rate data **{R6}**. They felt that the two measures were closely related and that this should be reflected in their on-screen positioning.

6.2 Guidelines – Overlaying Multiple Graphs

ID	Description	Conformance	Evidence Rating
GTAB-154	Graphs may be overlaid under certain circumstances (Example 83) The circumstances are: ■ If they share the same unit of measurement ■ If there is a special convention (such as in acute care vital signs charts where Blood Pressure and Pulse Rate share the same graph space)	Recommended	Medium

Usage Examples

Example 83: Overlay pulse rate and blood pressure



Rationale

CUI user research and reviews of existing use of paper charts shows that, within the NHS, there is a convention to overlay some data series (especially within acute care) **{R6}**.

For example, in the majority of paper charts, blood pressure and pulse rate are overlaid. Clinicians have come to expect this and may feel that not overlaying some data series could hinder their interpretation of them **{R6}**.

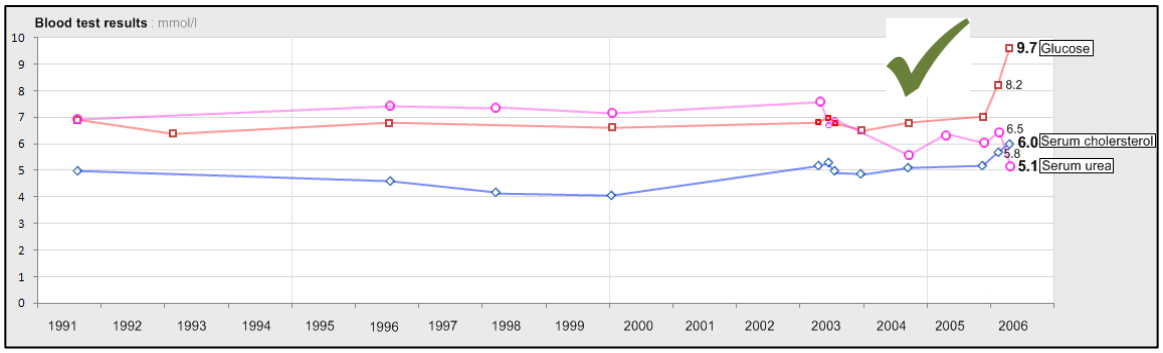
However, other research has shown that, without a good clinical reason to do so, overlaying data series on top of each other could be dangerous as the data points and interpolation can obstruct each other **{R3}**.

6.3 Guidelines – Special Considerations for Viewing Multiple Overlaid Graphs

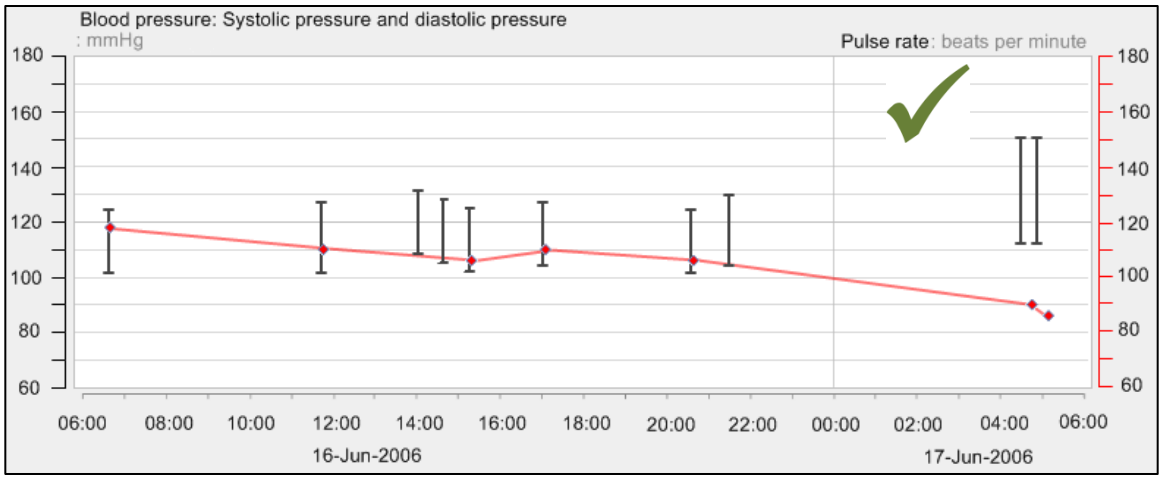
ID	Description	Conformance	Evidence Rating
GTAB-155	If two data series displayed in the same graph area are measured in different units, show both axes (Example 85)	Mandatory	Medium
GTAB-156	If two axes are shown, label each axis (Example 85)	Mandatory	High
GTAB-157	If two data series displayed in the same graph area are measured in different units and the axes gradation spacing is different, do not show horizontal gridlines	Mandatory	Medium
GTAB-158	When multiple data series are displayed in the same graph area, label each data series in an appropriate place (Example 84) Appropriate places are: ▪ At the end of the data series ▪ At the beginning of the data series If any labels overlap in either of these positions, display labels in a legend immediately adjacent to the graph area	Recommended	High
GTAB-159	Avoid distinguishing multiple data series displayed in the same graph area with varying line styles For example, lines styles using dashes or dots	Recommended	Low
GTAB-160	When multiple data series are displayed in the same graph area, display the interpolation lines as semi-transparent (Example 84)	Recommended	Low
GTAB-161	Avoid relying on the distinction between green and red when displaying multiple data series. If employing these colours, use another characteristic to distinguish them (such as shape)	Mandatory	High
GTAB-162	Where multiple data series are displayed in the same graph area, feature hollowed symbols, rather than the usual solid symbols (Example 84) An exception to this is blood pressure data where the systolic is linked to the diastolic pressure	Recommended	Low
GTAB-163	Where data points become tightly packed, reduce their size. However, do not reduce them to a height that is the same as or less than the width of the interpolation line (Example 86)	Recommended	Low

Usage Examples

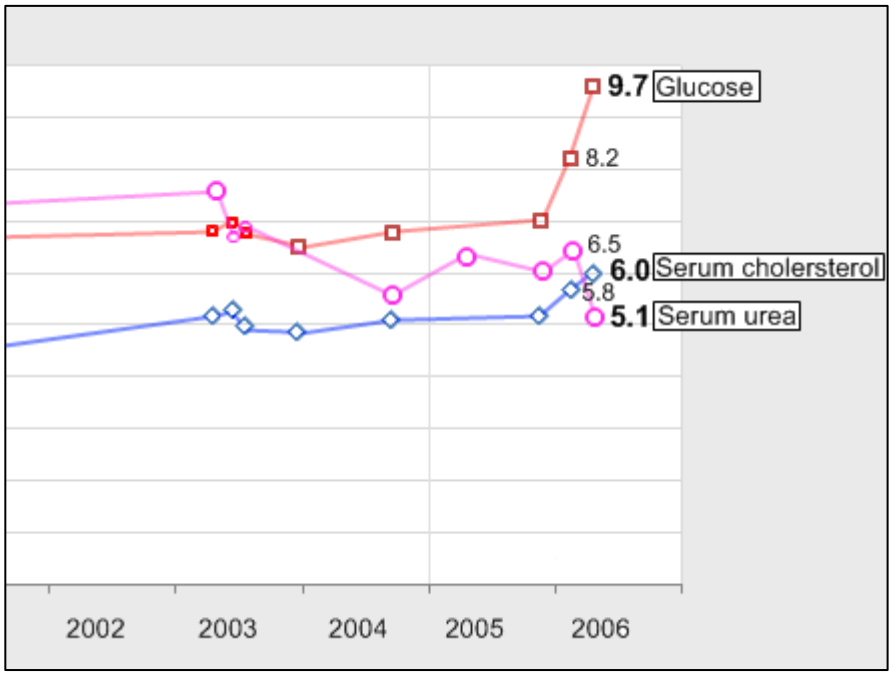
Example 84: Clearly overlay test results



Example 85: Show both axes when different data is overlaid



Example 86: Shrink the icons to allow tightly packed overlay



Rationale

Some perceptual psychology literature suggests that a good way to represent layers of data is to feature transparent objects that differ in pattern or texture **{R7}**. However, Stephen Few, a recognised expert in data visualisation, recommends avoiding varying lines styles unless no other attributes (such as colour) are available **{R8}**.

Shrinking the data points when they are tightly positioned is supported by studies in perception which suggest that reducing the density of information increases the useful field of view, a concept which describes a human's attention to objects within a 'single fixation' **{R7}**.

Avoiding reliance on a green-red colour distinction is important as the most common form of colour blindness causes sufferers to see these as the same colour.

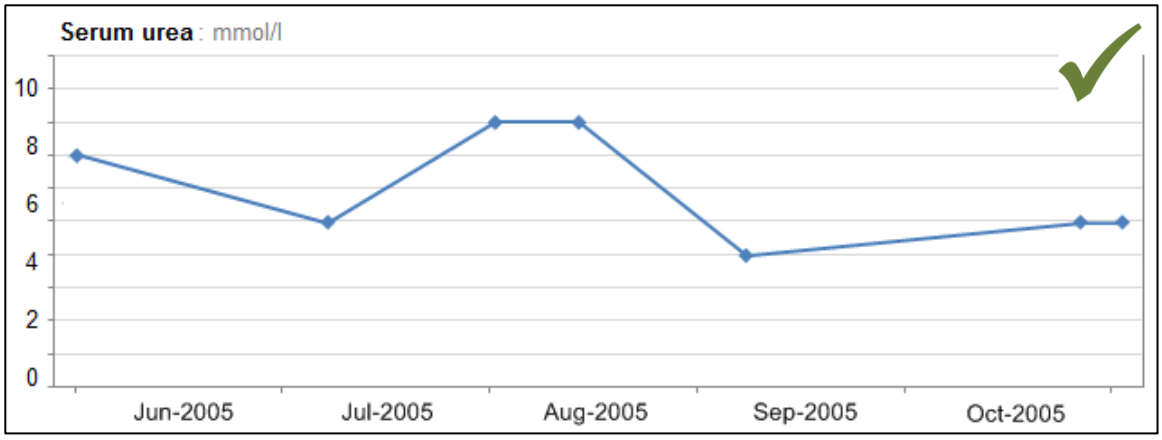
7 INTERPOLATION GUIDANCE DETAILS

7.1 Guidelines – Use of Interpolation

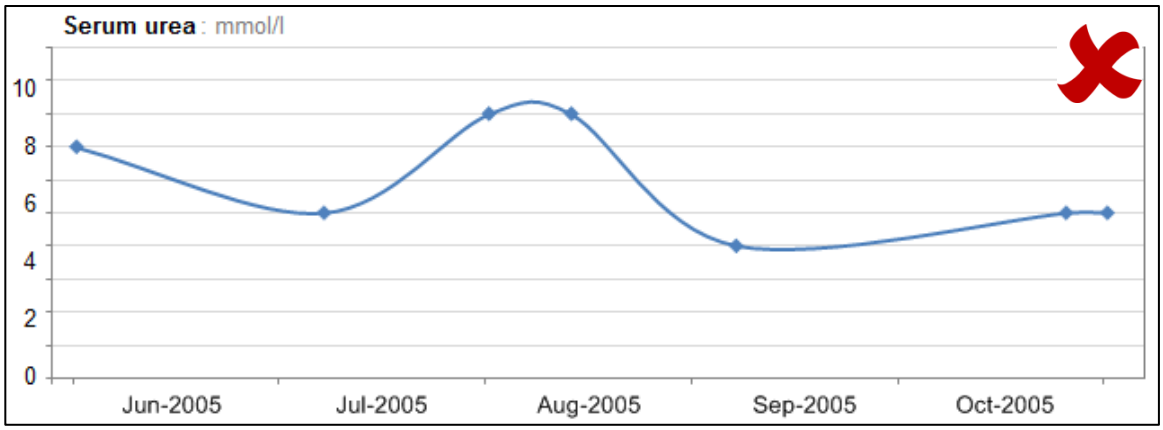
ID	Description	Conformance	Evidence Rating
GTAB-164	By default, with exceptions, provide interpolation between data points (Example 87) Exceptions to this are: ▪ Where the timing of the data is insufficiently specific for the scale (such as when the data point relates to a day and time but gradations of less than a day are shown) ▪ Where data is known to be missing. In these cases, do not use interpolation to cross a point where data is missing. Further mitigation would be required, such as a message that data is known to be missing, but this is out of scope for the current guidance	Mandatory	High
GTAB-165	Allows users to switch interpolation lines off	Recommended	Medium
GTAB-166	Interpolation should comprise straight lines between data points. By default, do not 'smooth' interpolation lines (Example 88) A 'smooth' interpolation line is one that is curved in order to better display the data pattern Although there may be circumstances where the ability to smooth out the interpolation can help clinicians to view the data patterns (such as for highly variable blood pressure data) this should not be the default view Data smoothing would require a carefully constructed algorithm in order to best represent the data pattern, but this is out of the scope for the current guidance	Recommended	High

Usage Examples

Example 87: Provide interpolation between data points



Example 88: Do not smooth interpolation lines



Rationale

CUI research has shown that clinicians understand the meaning of the interpolation between data points and they find it useful when interpreting graphical data. They realise that the interpolation does not represent actual data, but warn that steps need to be taken to ensure that the lines are not interpreted as such (for example, by ensuring that the data points are clearly visible) **{R5}**.

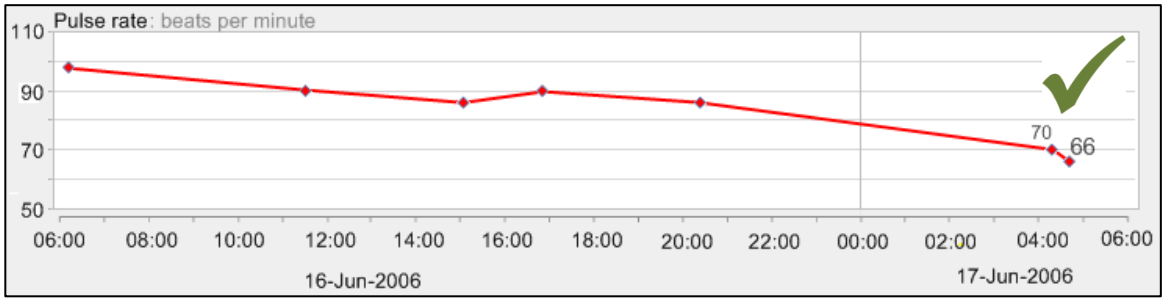
Research showed that clinicians thought that smoothing interpolation lines would be misleading and could lead to clinicians seeing peaks as being slightly higher than they should be **{R5}**.

7.2 Guidelines – Formatting of Interpolation

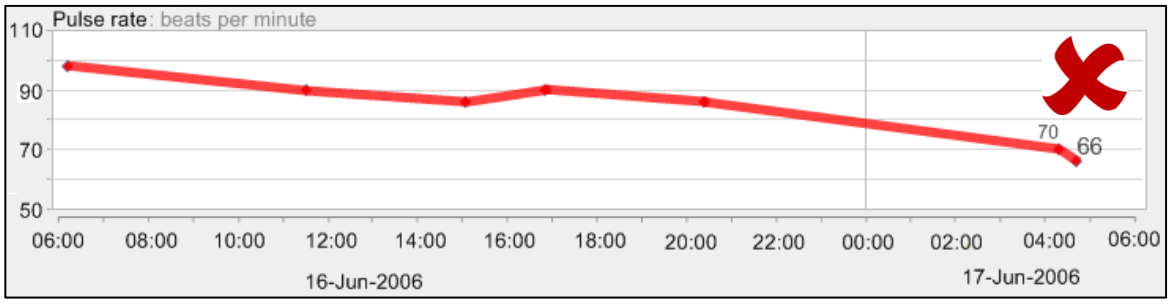
ID	Description	Conformance	Evidence Rating
GTAB-167	Interpolation lines should be solid (Example 89)	Recommended	Medium
GTAB-168	Interpolation lines should not obscure the data points (Example 90)	Mandatory	High
GTAB-169	Data value points should define the upper and lower points of the data sequence, not the interpolation lines Where interpolation lines connect a data point that is preceded by a lower value and followed by a lower value, the interpolation lines should not lie any higher than the upper edge of the data point symbol Where interpolation lines connect a data point that is preceded by a higher value and followed by a higher value, the interpolation lines should not lie any lower than the lower edge of the data point symbol	Mandatory	High
GTAB-170	Interpolation lines should be thinner than the data points they connect (Example 92, Example 93)	Mandatory	Medium
GTAB-171	Interpolation lines should be approximately half the height or diameter of the data points they connect	Recommended	Medium
GTAB-172	Interpolation lines should be the same colour as the data points they connect (Example 91)	Mandatory	Medium
GTAB-173	Interpolation lines should feature some anti-aliasing	Recommended	High

Usage Examples

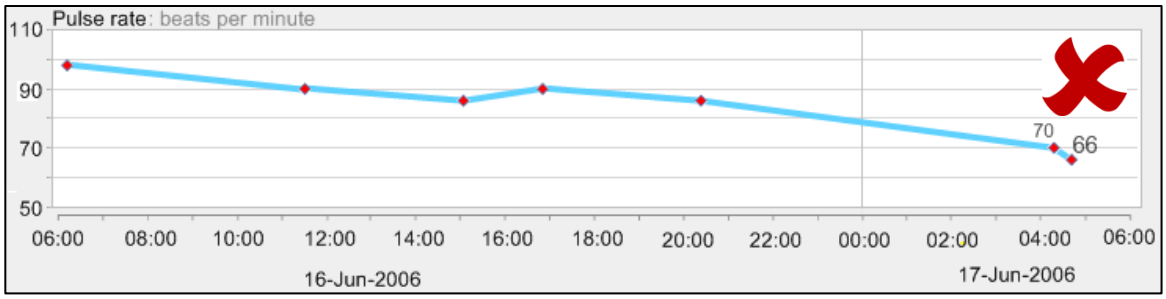
Example 89: Make interpolation solid, but not obscuring the data points



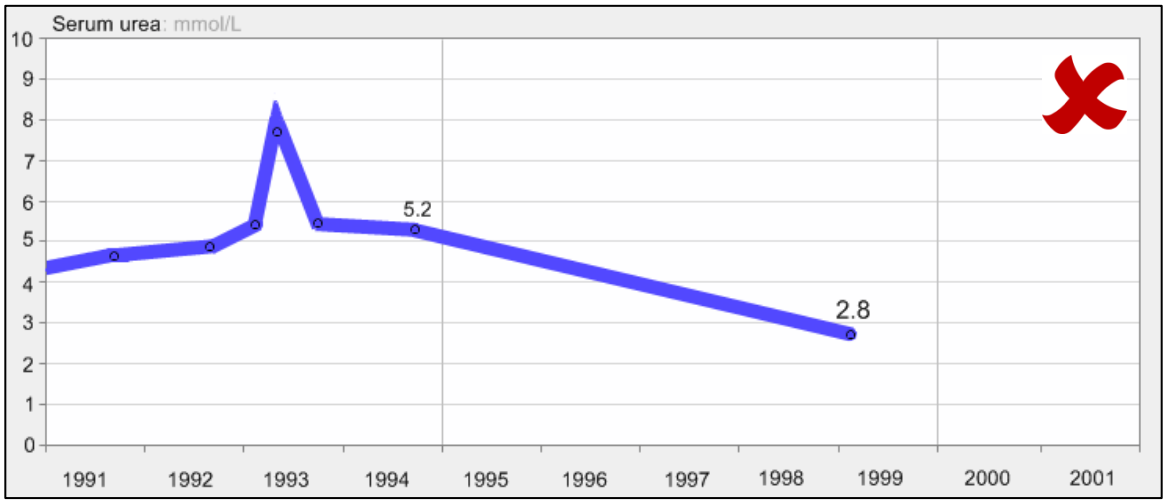
Example 90: Do not make interpolation lines thicker than the data points



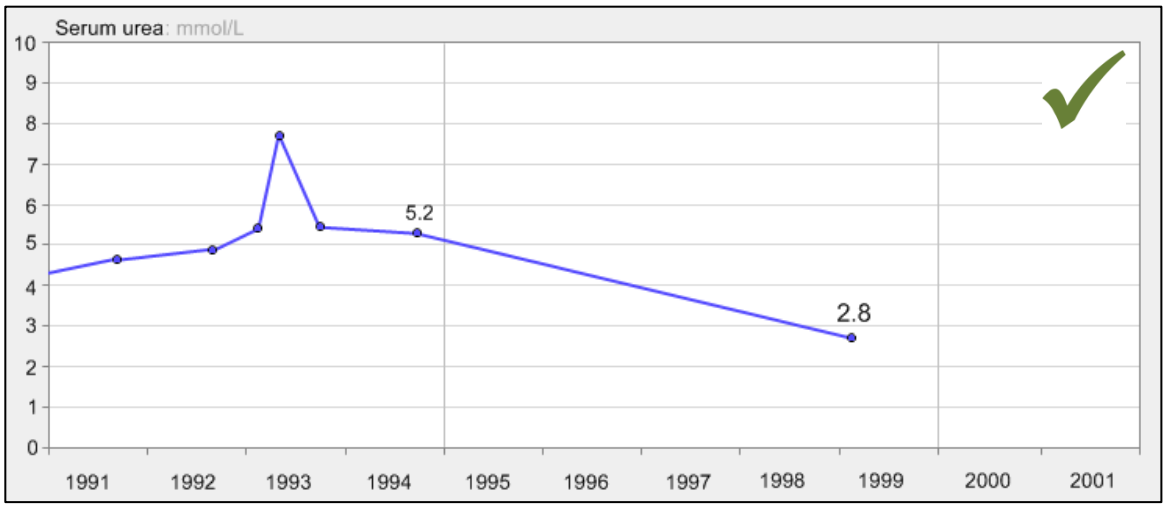
Example 91: Do not display interpolation lines in a different colour than the data points



Example 92: Do not create artificial peaks with a thick interpolation line



Example 93: Feature interpolation lines that are sufficiently thin so they do not obstruct the data points



Rationale

CUI research **{R5}** has revealed that clinicians are concerned that interpolation lines could be confused with actual data. There is a greater chance that this could happen if the reader cannot actually see the data points because the points are obscured by the interpolation line.

Not only can thicker lines hide the data points, they can also create visual peaks that do not exist in the data, which could have serious patient safety implications.

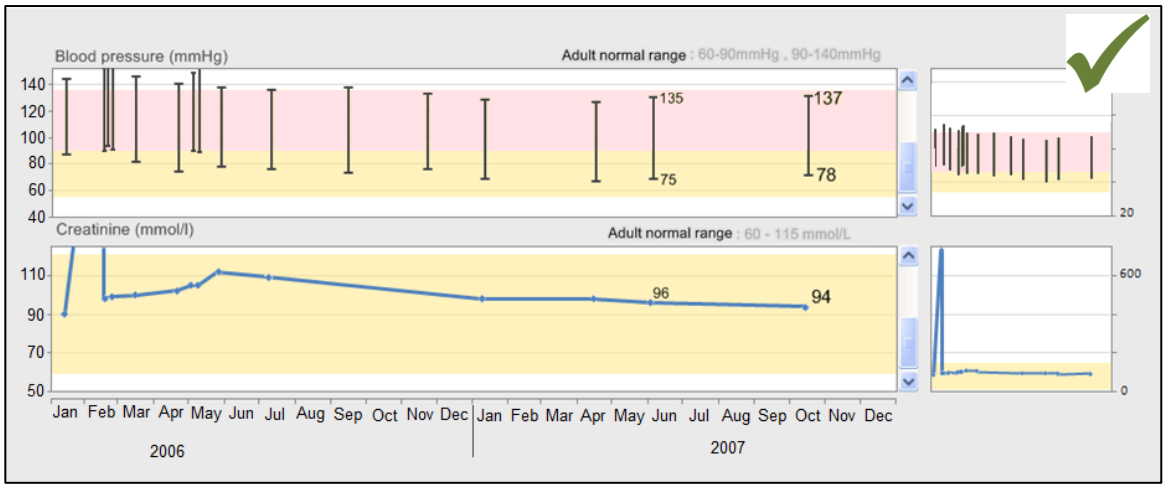
8 INDICATIVE RANGES GUIDANCE DETAILS

8.1 Guidelines – Displaying Indicative Ranges

ID	Description	Conformance	Evidence Rating
GTAB-174	Display normal ranges, but only where appropriate ranges exist (Example 94)	Recommended	High
GTAB-175	Display normal ranges consistently: either shade the out-of-range areas or shade the in-range areas. Do not feature both styles in the same system (Example 95)	Mandatory	Medium
GTAB-176	Where appropriate, display early warning scoring ranges graphically, but only in conjunction with a mechanism that displays the numerical scoring as well	Recommended	Medium
GTAB-177	Allow target ranges and critical thresholds to be displayed in addition to normal ranges	Mandatory	High
GTAB-178	Label indicative ranges with the population to which they refer (Example 94)	Mandatory	High
GTAB-179	Ensure that indicative range labels do not obstruct any data	Mandatory	Medium
GTAB-180	Where appropriate, adjust normal ranges to suit the specific population For example, the normal range is different for neonates	Mandatory	High
GTAB-181	Do not overlay multiple normal ranges on top of each other	Mandatory	Medium
GTAB-182	Feature normal ranges as areas rather than threshold lines	Recommended	Medium
GTAB-183	Feature normal range overlays in low-saturation colours (Example 95)	Recommended	Medium
GTAB-184	Normal range displays should not obscure any graph data Graph data includes such items as data points, data value labels, gridlines or interpolation lines	Mandatory	High
GTAB-185	Feature the systolic and diastolic normal ranges in different shades of colour (Example 95)	Recommended	Low

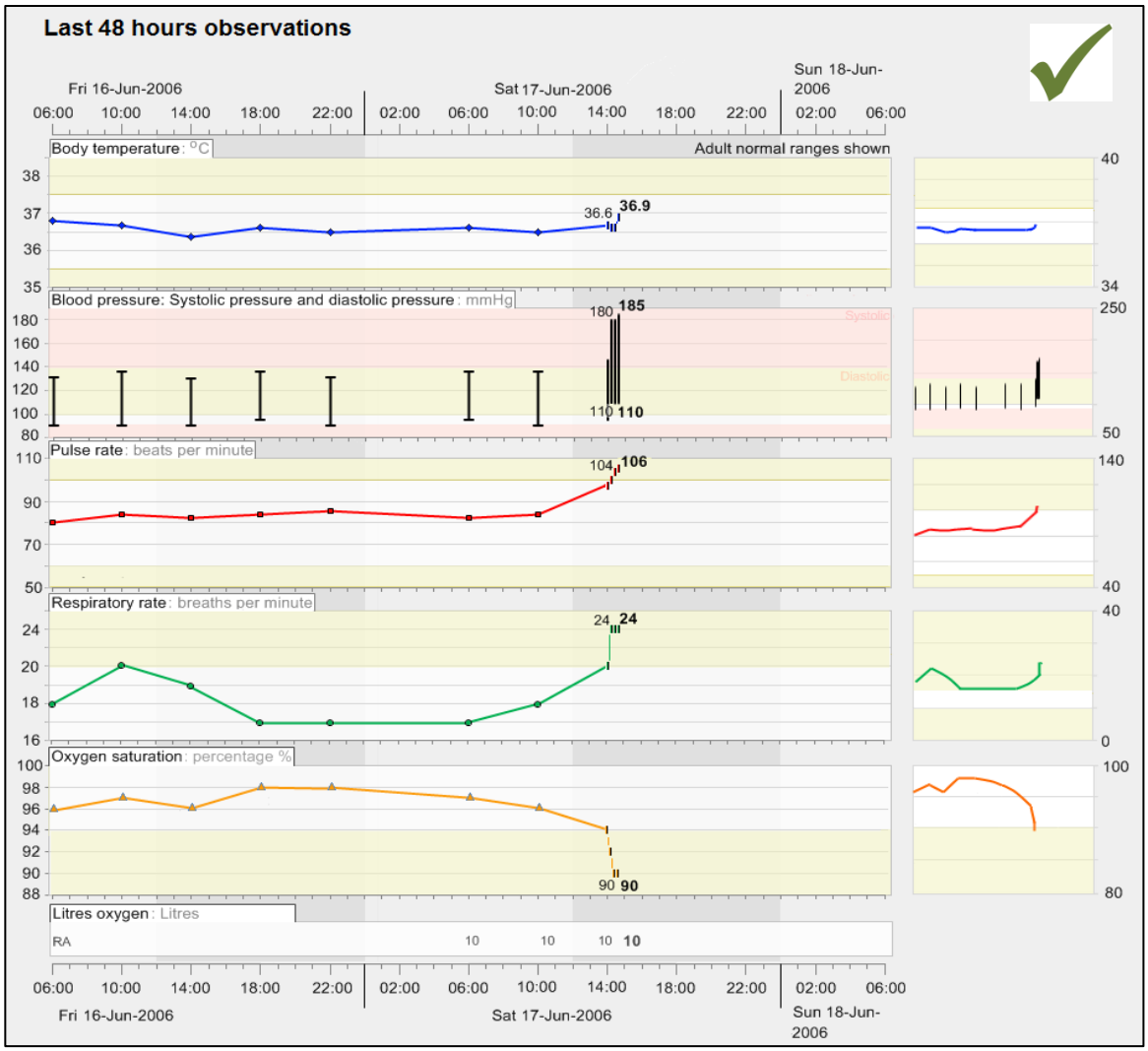
Usage Examples

Example 94: Display adult normal ranges, where appropriate



In this illustration, both sets of measures have ranges (based upon a normal adult population). The ranges are displayed as yellow shading, although this could be reversed (see Example 95). The ranges are labelled and, in this case, the range parameters are displayed.

Example 95: Display ranges consistently



In this example, the normal ranges are shown as the white area and the shaded areas represent out-of-range.

Employ either shading method to represent normal ranges or to represent abnormal ranges. The method to use may depend on whether the values are more or less likely to fall within the normal range in the particular clinical setting. If the data is more likely to fall within the normal range, there is a case for shading the out-of-range as the usual data points will then better contrast with a white background.

However, do not mix the two methods in the same clinical setting (or clinical software) as swapping the meaning of the shading could carry significant patient safety risks.

Rationale

The display of normal ranges plays a crucial role in the interpretation of clinical data (such as vital signs). On the one hand, they highlight where the current data is indicating a problem with the patient. On the other hand, they can provide a useful reference to help the clinician quickly perceive the values of the data points (for example, if the data appears a certain distance above a normal range, the clinician can quickly understand the approximate values of the data).

Normal ranges typically comprise the upper and lower parameters of 'normality' for a given population, typically a healthy adult population (that is, a range in which a reading does not by itself indicate a problem with the patient).

CUI research **{R5, R6}** revealed that, despite the display of normal ranges being considered important, if not necessary, by clinicians, most felt that the notion of what is 'normal' varied so much between populations and medical situations that displaying a fixed normal range could be dangerous. For example, showing an eight-month baby's blood pressure in relation to an adult normal range could lead the clinician to conclude that the patient is healthy when in fact their signs should raise warnings.

For this reason, the majority of clinicians indicated that, in order to work safely, normal range markings on graphs should be adjusted to the given population (for example, determined by age).

Coupled with displaying adjusted normal ranges is the requirement to clearly communicate the range that is being displayed. This is critical as the research revealed that some clinicians often assume the normal range shown is for an adult and mentally adjusts it in order to interpret the data. It would be dangerous if the clinician assumed that the range for an eight month child was, in fact, for an adult and incorrectly compensated for this when interpreting the data.

The importance of displaying normal ranges on graphs has been reflected in recent work in other areas of the NHS, as in the case of the 'North Hospital' research **{R15}** that has resulted in the creation of a standardised paper observations chart that features early warning scoring parameters overlaid on the graph areas.

An advantage of displaying normal ranges as areas rather than simply threshold lines is that it is easier to see the range as a whole object. Also, shaded ranges are less likely to interfere with the display of single threshold lines. Single threshold lines can be added to the graph by a clinician so that readings above (or below) the threshold value would trigger a call to the clinician from the nurse.

During the CUI research, clinicians were presented with the normal ranges as shaded areas and they immediately understood what they were **{R6}**.

Ranges can be used as part of early warning scoring systems. The NICE guidelines on the *Recognition of and response to acute illness in adults in hospital* **{R1},** recommends the use of early warning scoring systems, such as PARS and MEWS. The NICE guidance also discusses the risks of not featuring such scoring systems to assist clinicians interpret observations data and to recognise the early signs of deterioration.

9 TABLES GUIDANCE DETAILS

Tables are an important medium for displaying clinical data. They are not as effective as graphs at revealing trends – and can be off-putting to the reader, especially if large – but tables possess some unique benefits over graphs:

- They can hold many data cells
- They can allow numeric data to be extracted easily and accurately
- They can easily accommodate wide ranges of data

Graphs emphasise the patterns and trends in data, but do not make the extraction of the values as easy as a table and cannot always easily present data with wide discrepancies of scale.

This section outlines the key factors to consider when creating tables that are safe and easy to use.

9.1 Guidelines – Table Orientation

ID	Description	Conformance	Evidence Rating
GTAB-186	Orient tables in a consistent manner, for a given data type and/or clinical setting or procedure	Mandatory	High
GTAB-187	Tables should follow a conventional orientation if one exists	Mandatory	High
GTAB-188	If a table is oriented with time ordered horizontally, by default the most recent data value must appear at the far right-hand side (that is, sorted from left-to-right) (Example 96) while ensuring that the most recent values are visible by default	Recommended	High
GTAB-189	If a table is oriented with time ordered vertically, by default the most recent data value must appear at the top of the table (that is, sorted from bottom-to-top) (Example 97) while ensuring that the most recent values are visible by default	Recommended	High
GTAB-190	Users must be able to re-sort data within the columns or rows	Recommended	High
GTAB-191	Users must be able to re-orient the table (that is, transpose the rows to columns and vice versa)	Recommended	High

Usage Examples

Example 96: Display the most recent data to the right of a horizontally oriented table

Date	25-Jun-2008	25-Jun-2008	25-Jun-2008	25-Jun-2008	26-Jun-2008	26-Jun-2008	26-Jun-2008	26-Jun-2008	26-Jun-2008
Time	21:37	21:59	22:00	23:00	00:00	02:00	04:00	06:00	10:00
Seconds									
Systolic pressure	142	142	140	140	142	138	140	140	138
Diastolic pressure	86	90	90	90	92	90	86	92	90
Heart rate	110		85	80	78	80	82	84	78
Serum cholesterol									
Serum urea									

Example 97: Tables with time running vertically should be ordered with the most recent reading at the top by default

Date	Day	Time	Systolic pressure	Diastolic pressure	Heart rate	Serum cholesterol	Serum urea
15-Aug-2008	Fri	22:00	134	86	72		
15-Aug-2008	Fri	18:00	132	82	70		
15-Aug-2008	Fri	14:00	132	84	72		
15-Aug-2008	Fri	10:00	134	86	72		
15-Aug-2008	Fri	06:00	146	92	80		
15-Aug-2008	Fri					7.2	
01-Jul-2008	Tue					6.3	6.2
30-Jun-2008	Mon		140	90	80		
26-Jun-2008	Thu	22:00	136	84	72		
26-Jun-2008	Thu	18:00	134	86	74		
26-Jun-2008	Thu	14:00	134	84	80		
26-Jun-2008	Thu	10:00	138	90	78		

Example 98: Do not sort time from top-to-bottom in a vertically oriented table by default

Date	Time	Systolic pressure	Diastolic pressure	Heart rate	Serum cholesterol	Serum urea
25-May-2006		143	85	80		
07-Jul-2006		141	83	78		
12-Sep-2006		142	81	80		
19-Nov-2006		138	83	82		
07-Jan-2007		143	85	78		
13-Apr-2007		142	83	80		
01-Jun-2007		145	85	80		
12-Oct-2007		147	88	82		
25-Jun-2008	21:37	142	86	110		
26-Jun-2008	22:00	136	84	72		
30-Jun-2008		140	90	80		
01-Jul-2008					6.3	6.2
15-Aug-2008					7.2	
15-Aug-2008	06:00	146	92	80		
15-Aug-2008	10:00	134	86	72		
15-Aug-2008	14:00	132	84	72		
15-Aug-2008	18:00	132	82	70		
15-Aug-2008	22:00	134	86	72		

Rationale

Following CUI research, this guidance concludes that there is no one way that clinicians must orient their data. Some clinicians expressed a preference for viewing tables that had time running vertically down them, whereas others felt more comfortable with a horizontal time axis **{R5}**.

Other studies have shown that there are benefits to either orientation, although certain actions are easier to do with one of the orientations. For example, scanning through information for particular values is easier with time vertically oriented **{R2, R8}**, as is interpreting trends from the data.

On the other hand, some clinicians feel that the progression of time is easier to understand when it is oriented horizontally, akin to the graph's x-axis. As the relevant BSi standard (7581) states, 'Rows are easier to read than columns, but columns are easier to scan.…The reader's need to scan tables should influence which information should be in rows and which in columns.' **{R2}**.

Therefore the current guidance is not mandating the use of one or other orientation. However, the default orientation of the table should remain consistent for a given clinical situation or data type. For example, if blood tests in a GP software programme are displayed by default with a vertical time axis on one day, a vertical time axis should be the default on a later day, unless there is a clinical reason to do otherwise.

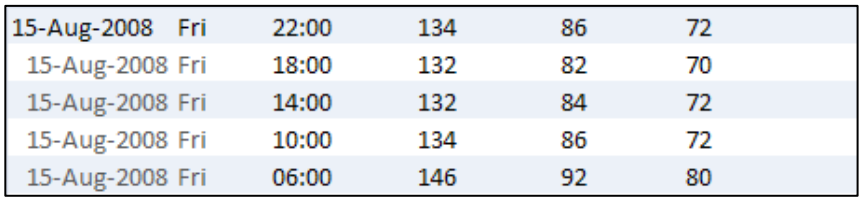
The basic designs shown in this section have been tested by CUI research **{R5}**. The research demonstrated that clinicians found the tables to be clear.

9.2 Guidelines – Table Formatting

ID	Description	Conformance	Evidence Rating
GTAB-192	Feature light banding along the rows (Example 99)	Recommended	High
GTAB-193	Do not feature heavy gridlines (Example 102)	Recommended	High
GTAB-194	Round data displayed in table cells entries where it is not misleading to do so	Mandatory	Medium
GTAB-195	If numeric entries are rounded, the table must communicate that the data is rounded and the extent to which it is rounded	Mandatory	Medium
GTAB-196	If appropriate, allow users to read the full version of any rounded data	Mandatory	Medium
GTAB-197	Ensure that where there are multiple instance of the same date, or times within a date, the first instance is more visually prominent than those following (Example 103)	Recommended	Medium
GTAB-198	Do not stretch tables to fill available space (this impedes horizontal scanning)	Recommended	Medium
GTAB-199	Feature extra spacing every fifth row (this assists vertical scanning)	Recommended	Medium
GTAB-200	Use a constant horizontal spacing for numerals (this ensures vertical alignment)	Mandatory	Medium
GTAB-201	Align the decimal marker for all numerals in a column	Mandatory	Medium
GTAB-202	If some numbers in a column do not feature a decimal place, but others do, do not add an unnecessary decimal place but instead provide padding within cells to allow for decimals (Example 100) For example, appending '.0' to a value is adding an unnecessary decimal place	Recommended	Low

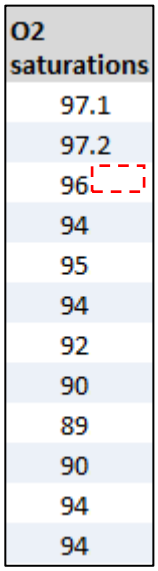
Usage Examples

Example 99: Feature a light banding on the rows



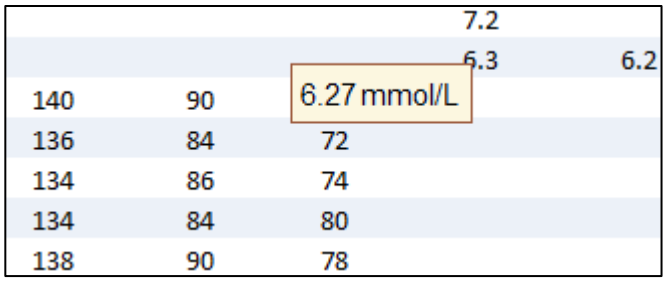
15-Aug-2008	Fri	22:00	134	86	72
15-Aug-2008	Fri	18:00	132	82	70
15-Aug-2008	Fri	14:00	132	84	72
15-Aug-2008	Fri	10:00	134	86	72
15-Aug-2008	Fri	06:00	146	92	80

Example 100: Provide padding to allow for alignment with the decimal point (as shown with the red box)



O2 saturations
97.1
97.2
96
94
95
94
92
90
89
90
94
94

Example 101: Allow clinicians to view the full number for a rounded value



Example 102: Do not feature heavy gridlines

Date	Time	Systolic pressure	Diastolic pressure	Heart rate	Serum cholesterol	Serum urea
25-May-2006		143	85	80		
07-Jul-2006		141	83	78		
12-Sep-2006		142	81	80		
19-Nov-2006		138	83	82		
07-Jan-2007		143	85	78		
13-Apr-2007		142	83	80		
01-Jun-2007		145	85	80		
12-Oct-2007		147	88	82		
25-Jun-2008	21:37	142	86	110		
25-Jun-2008	21:59	142	90			

Example 103: Ensure that the first instance of each set of dates is more prominent than those following

Date	Day	Time	Systolic pressure	Diastolic pressure	Heart rate	Serum cholesterol	Serum urea
15-Aug-2008	Fri	22:00	134	86	72		
15-Aug-2008	Fri	18:00	132	82	70		
15-Aug-2008	Fri	14:00	132	84	72		
15-Aug-2008	Fri	10:00	134	86	72		
15-Aug-2008	Fri	06:00	146	92	80		
15-Aug-2008	Fri					7.2	
01-Jul-2008	Tue					6.3	6.2
30-Jun-2008	Mon		140	90	80		
26-Jun-2008	Thu	22:00	136	84	72		
26-Jun-2008	Thu	18:00	134	86	74		
26-Jun-2008	Thu	14:00	134	84	80		
26-Jun-2008	Thu	10:00	138	90	78		

Rationale

Most of the guidelines featured in this section are based upon BSI Standard 7581 **{R2}**, plus best practice in table design **{R8}**. The CUI research team **{R5}** has also presented the basic elements of the preferred designs to clinicians and have found no problems with the designs.

9.3 Guidelines – Table Labelling

ID	Description	Conformance	Evidence Rating
GTAB-203	Align column headings with their associated data (Example 104)	Recommended	Medium
GTAB-204	If column headings are centred, they should be visually aligned over the column of data	Recommended	Medium
GTAB-205	As far as possible, word row titles so they are of similar length	Recommended	Medium
GTAB-206	Long row headings may be split into two or more lines, with the data aligning with the bottom line (Example 105)	Recommended	Medium
GTAB-207	Avoid a heading that is significantly wider than the data it is indicating (Example 106)	Recommended	Medium
GTAB-208	Keep column headings brief	Recommended	Medium
GTAB-209	Clearly link column headings to their columns	Mandatory	Medium
GTAB-210	Top align column headings	Recommended	Medium
GTAB-211	In wide tables, row headings may be provided at both ends of the row	Recommended	Medium
GTAB-212	Allow sufficient space between columns to clearly separate them but no more (excessive space impedes horizontal scanning) (Example 104, Example 106)	Recommended	Medium
GTAB-213	Do not display column headings vertically	Mandatory	Medium
GTAB-214	Column headings may be displayed at 45° to the column, if the heading is too long to display horizontally and cannot be wrapped adequately	Recommended	Medium
GTAB-215	Provide special formatting if column headings are displayed at 45° so that it is clear which heading applies to which column (Example 108)	Recommended	Medium
GTAB-216	Do not alternate between the directions of the 45° oriented text in the same table That is, do not direct one column heading to the left and another to the right in the same table	Recommended	Low
GTAB-217	Always display both column and row headings	Mandatory	High
GTAB-218	Ensure that the column and row headings are always visible This may involve 'freezing' the column and/or row headings	Mandatory	Medium

Usage Examples

Example 104: Align column headings with their associated data

Date	Day	Time	Systolic pressure	Diastolic pressure	Heart rate	Serum cholesterol	Serum urea
15-Aug-08	Fri	22:00	134	86	72		
15-Aug-08	Fri	18:00	132	82	70		
15-Aug-08	Fri	14:00	132	84	72		
15-Aug-08	Fri	10:00	134	86	72		
15-Aug-08	Fri	06:00	146	92	80		
15-Aug-08	Fri					7.2	
01-Jul-08	Tue					6.3	6.2
30-Jun-08	Mon		140	90	80		
26-Jun-08	Thu	22:00	136	84	72		
26-Jun-08	Thu	18:00	134	86	74		

Example 105: If a row heading is wrapped, align the data with the bottom line

Date	25-Jun-2008	25-Jun-2008	25-Jun-2008	25-Jun-2008	26-Jun-2008	26-Jun-2008
Time	21:37	21:59	22:00	23:00	00:00	02:00
Systolic pressure	142	142	140	140	142	138
Diastolic pressure	86	90	90	90	92	90
Heart rate	110		85	80	78	80
Serum cholesterol						
Serum urea						

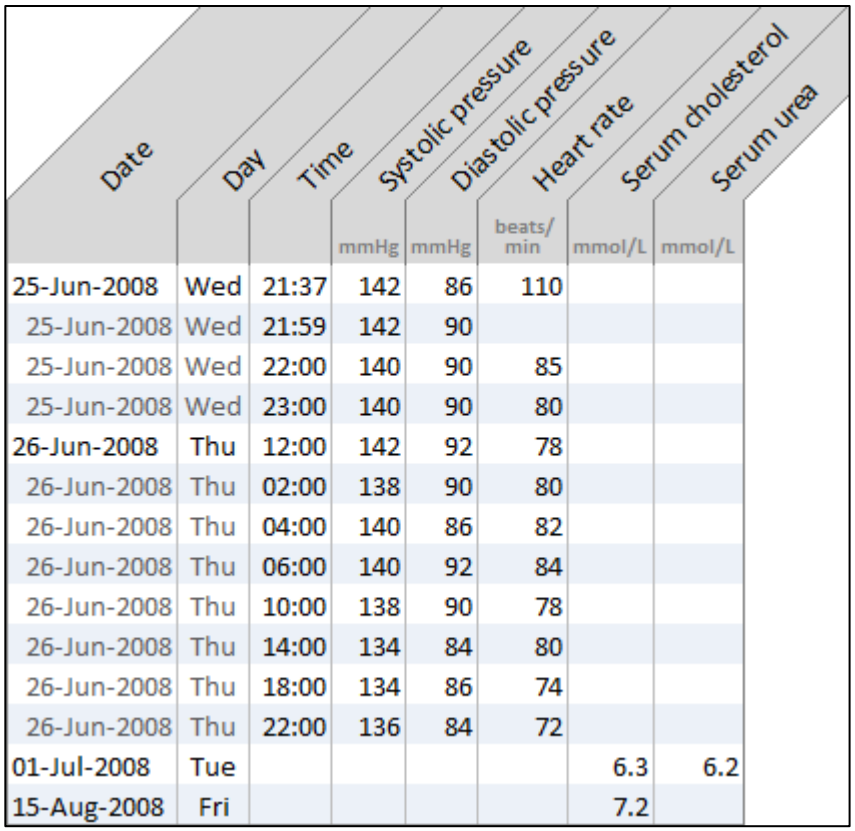
Example 106: Avoid excessive spacing between columns

Systolic pressure	Diastolic pressure	Heart rate	Serum cholesterol
142	86	110	
142	90		
140	90	85	
140	90	80	
142	92	78	
138	90	80	
140	86	82	
140	92	84	
138	90	78	
134	84	80	
134	86	74	
136	84	72	
140	90	80	
			6.3
			7.2
146	92	80	
134	86	72	

Example 107: Do not use diagonal formatting without linking the heading to the column

Date	Day	Time	Systolic pressure	Diastolic pressure	Heart rate	Serum cholesterol	Serum urea
			mmHg	mmHg	beats/ min	mmol/L	mmol/L
25-Jun-2008	Wed	21:37	142	86	110		
25-Jun-2008	Wed	21:59	142	90			
25-Jun-2008	Wed	22:00	140	90	85		
25-Jun-2008	Wed	23:00	140	90	80		
26-Jun-2008	Thu	12:00	142	92	78		
26-Jun-2008	Thu	02:00	138	90	80		
26-Jun-2008	Thu	04:00	140	86	82		
26-Jun-2008	Thu	06:00	140	92	84		
26-Jun-2008	Thu	10:00	138	90	78		
26-Jun-2008	Thu	14:00	134	84	80		
26-Jun-2008	Thu	18:00	134	86	74		
26-Jun-2008	Thu	22:00	136	84	72		
01-Jul-2008	Tue					6.3	6.2
15-Aug-2008	Fri					7.2	

Example 108: Feature diagonal labelling with light gridlines to associate the heading with the column



Date	Day	Time	Systolic pressure	Diastolic pressure	Heart rate	Serum cholesterol	Serum urea
			mmHg	mmHg	beats/ min	mmol/L	mmol/L
25-Jun-2008	Wed	21:37	142	86	110		
25-Jun-2008	Wed	21:59	142	90			
25-Jun-2008	Wed	22:00	140	90	85		
25-Jun-2008	Wed	23:00	140	90	80		
26-Jun-2008	Thu	12:00	142	92	78		
26-Jun-2008	Thu	02:00	138	90	80		
26-Jun-2008	Thu	04:00	140	86	82		
26-Jun-2008	Thu	06:00	140	92	84		
26-Jun-2008	Thu	10:00	138	90	78		
26-Jun-2008	Thu	14:00	134	84	80		
26-Jun-2008	Thu	18:00	134	86	74		
26-Jun-2008	Thu	22:00	136	84	72		
01-Jul-2008	Tue					6.3	6.2
15-Aug-2008	Fri					7.2	

> **Note**
>
> In this example, the display order of the rows has been changed from the default order (most recent displayed at the top of the table).

Rationale

Most of the guidelines featured in this section are based upon BSI 7581 **{R2}**, plus best practice in table design **{R8}**. The CUI research team **{R5}** has also presented the basic elements of the preferred designs to clinicians and have found no problems with the designs.

10 CONTEXTUAL INFORMATION GUIDANCE DETAILS

10.1 Guidelines – Accessing Contextual Data

ID	Description	Conformance	Evidence Rating
GTAB-219	Provide contextual information about the way in which the reading was taken For example, 'manual' or 'machine' reading	Mandatory	High
GTAB-220	Make visible the contextual information about how the reading was taken by default	Mandatory	High
GTAB-221	Allow the user to interrogate the system to access further contextual information	Mandatory	High
Rationale			
From the CUI research, it is clear that contextual information affects the way in which the data can be interpreted. It is important that the graph interface provides sufficient labelling and/or access to further information (such as the method of measurement or the environment in which the reading was taken).			

11 Document Information

11.1 Terms and Abbreviations

Abbreviation	Definition
A&E	Accident and Emergency
BSI	British Standards Institution
CUI	Common User Interface
ISO	International Standards Organization
MEWS	Modified Early Warning Score
NHS	National Health Service
NHS CFH	NHS Connecting for Health
O2	Oxygen
PARS	Patient At-Risk Scores
RNIB	Royal National Institute of Blind People
SNOMED-CT	Systematised Nomenclature of Medicine-Clinical Terms
UI	User Interface
WAI	Web Availability Initiative
W3C	World Wide Web Consortium

Table 14: Terms and Abbreviations

11.2 Definitions

Term	Definition
NHS Entity	Within this document, defined as a single NHS organisation or group that is operated within a single technical infrastructure environment by a defined group of IT administrators.
The Authority	The organisation implementing the NHS National Programme for IT (currently NHS Connecting for Health).
Current best practice	Current best practice is used rather than best practice, as over time best practice guidance may change or be revised due to changes to products, changes in technology, or simply the additional field deployment experience that comes over time.
Normal range	A clinically relevant range for a data series, defined by an upper and a lower parameter, that expresses the normal values expected for a given healthy population, in isolation to other data series. Values that fall outside of a normal range may potentially indicate a health problem and a cause for concern. Which normal range applies to a given patient may depend upon certain aspects of their individual demography. For example, the age or gender of the patient may determine which normal range applies to them at a given point in time.
Target range or threshold	A range, or a point above or below a threshold, associated with a positive health outcome that is formulated by the care giver when planning and delivering the patient's care. Unlike normal ranges, target ranges and thresholds are patient-specific, rather than population-specific.

Term	Definition
Critical range or threshold	A range, or a point above or below a threshold, associated with a negative health outcome that is formulated by the care giver when planning and delivering the patient's care. Typically, if data values fall within such a range (or above or below such a threshold) warnings should be raised, such as a nurse contacting the doctor. This type of range or threshold is patient-specific rather than population-specific.
Reference range	A standard range that helps the viewer of a graph understand the absolute values (or at least the significance) of the data points by locating their position in relation to the range. A reference range may comprise a normal range.
Indicative range	Same as 'Reference range'.
Scale	The relationship between the physical distances displayed in the graph and the relationships between the underlying data values. For example, an hour may be represented by a distance of 10 mm running from left-to-right along the (horizontal) x-axis plane, while a rise of 10 mmHg of systolic pressure may be represented by 5 mm running from bottom-to-top along the (vertical) y-axis plane. References to 'scale' include both the x-axis and y-axis scales, as it is often the ratio between these two that is important to the clinician's interpretation of the data.
Axes	The orthogonal (perpendicular) planes that represent data continuums, such as 'pulse rate'. On a two dimensional graph area, there will be a minimum of two axes, the x- and y-axis, one of those being 'time'. In special cases of overlaid data, there may be three axes in the same graph area.
X-axis	The x-axis marks the horizontal scale and is orthogonal to the y-axis.
Y-axis	The y-axis marks the vertical scale and is orthogonal to the x-axis.
Axis range	The range of potential values shown in the graph along a single axis in a view.
Axis marking	Markings of data increments along the axes.
Gridlines	Horizontal and/or vertical lines shown on the graph area aligned with regular increments in the data. The purpose of these lines is to help the viewer identify the values of the data points.
Data point	A visual representation of a data value.
Data unit	The measurement units in which a data series is being expressed, such as 'beats per minute'.
Data series	A set of data of a single measurement type, such as 'pulse rate' or 'body temperature'.
Interpolation	Lines added to the graph that sequentially join up the data points. Interpolation assists the perception of the data values and the patterns in which they fall.
Graph area	The two-dimensional blank space in which data points may be displayed.
Logarithmic scaling	Scaling where a series of numbers are produced by increasing the power of a base number by one for each sequential interval.

Table 15: Definitions

11.3 Nomenclature

This section shows how to interpret the different styles used in this document to denote various types of information.

11.3.1 Body Text

Text	Style
Code	`Monospace`
Script	
Other markup languages	
Interface dialog names	**Bold**
Field names	
Controls	
Folder names	Title Case
File names	

Table 16: Body Text Styles

11.3.2 Cross References

Reference	Style
Current document – sections	Section number only
Current document – figures/tables	Caption number only
Other project documents	*Italics* and possibly a footnote
Publicly available documents	*Italics* with a footnote
External Web-based content	*Italics* and a hyperlinked footnote

Table 17: Cross Reference Styles

11.4 References

Reference	Document	Version
R1.	National Institute for Health and Clinical Excellence: Acutely ill patients in hospital: Recognition of and response to acute illness in adults in hospital: http://www.nice.org.uk/CG50	July 2007
R2.	British Standards Institute: Guide to Presentation of tables and graphs: British Standard BS 7581: 1992	
R3.	Design Guide Entry – Date Display	3.0.0.0
R4.	Design Guide Entry – Time Display	3.0.0.0
R5.	NHS CUI Research Study ID 2	
R6.	NHS CUI Research Study ID 39	
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Table 18: References

APPENDIX A HIGH-LEVEL TASK SCENARIOS

The following scenarios were developed in order to represent how graphs and tables could be used within a clinical setting. They were originally written in collaboration with the CUI clinical specific audience and then validated with a wider set of clinicians. Designs were built around these scenarios and these led, in part, to the creation of the guidance.

PART I Emergency Department Assessment

Emergency Department Assessment	
A nurse is performing an initial assessment on a patient who has been brought in by ambulance into her Accident and Emergency (A&E) ward complaining of chest pains. The nurse reads the set of observations recorded by paramedics and then records the patient's vital signs onto their chart. Comparing the two charts, the nurse notices that the patient's blood pressure has dropped significantly, the respiratory rate has increased slightly and oxygen, pulse and temperature have remained constant.	
High Level Tasks	▪ Read the current data values ▪ Check the provenance of the data values ▪ Compare the current data values with past readings ▪ Check for significant interactions between data series

Potential Risks	High:
	▪ Nurse fails to either view the previous (ambulance) data or fails to recognise when it was taken
	▪ Nurse fails to identify the drop in blood pressure as being significant
	  ▪ They fail to see how much it has dropped
	  ▪ They fail to see how quickly it has dropped
	Medium:
	▪ Nurse fails to see the drop in blood pressure in the context of the oxygen, pulse and temperature remaining constant
	Low:
	▪ Nurse fails to see that the respiratory rate has increased slightly
	▪ Nurse does not correctly read the absolute values of the blood pressure
	▪ Nurse does not correctly read the absolute values of the respiratory rate oxygen, pulse and temperature.
	▪ Nurse does not factor in that the differences in readings may be fully or partially accounted for by the change in settings in which the readings were taken
	Possible consequence of risks: Delayed diagnosis or understanding of problem

Key Feature Areas	Most Significant: ▪ Intuitive and appropriate scaling ▪ Viewing trends and interactions, including interpolation Quite Significant: ▪ Simultaneous views of multiple data series ▪ Clear and appropriate axes Reasonably Significant: ▪ Access to and display of supporting contextual data ▪ Support for baseline deviation calculations Basic Practice: ▪ Clear presentation of data values and units ▪ Appropriate layout, density and formatting of graph spaces, values and text

PART II Intensive Care Unit Monitoring

Intensive Care Unit Monitoring

A paediatrics consultant is called to see a baby with meningitis who isn't passing urine.

On the way to the baby, the consultant reads a summary of the patient's history.

The consultant then views the chart and sees, among other observations, that the baby's blood pressure is high while the oxygen saturations are low and the pulse has been rising. The baby's high temperature also indicates pyrexia.

The consultant suspects that the baby is fluid overloaded.

The consultant puts the baby onto a ventilator and prescribes Forusemide.

The consultant then monitors the baby at regular intervals to check the baby's progress.

High Level Tasks	▪ Read the current data values ▪ Check if the current data values fail to exceed or fall below a threshold ▪ Check for significant patterns over time in a series of data values ▪ Check for significant interactions between data series

Potential Risks	High:
	▪ Consultant fails to see the current configuration of the vital signs (for example, high, low, rising)
	▪ Consultant fails to understand the current configuration of the vital signs in relation to the patient's usual levels
	Medium:
	▪ Consultant fails to identify the rise in blood pressure and pulse as significant:
	  ▪ Fails to see how much they had risen
	  ▪ Fails to see how quickly they had risen
	▪ Consultant fails to identify the drop in oxygen saturations as significant:
	  ▪ Fails to see how much they had dropped
	  ▪ Fails to see how quickly they had dropped
	Possible consequence of risks: Incorrect treatment

Key Feature Areas	Most Significant: ▪ Simultaneous views of multiple data series ▪ Intuitive and appropriate scaling ▪ Viewing data values in relation to normal ranges, targets and thresholds Quite Significant: ▪ Clear and appropriate axes ▪ Viewing trends and interactions, including interpolation ▪ Support for baseline deviation calculations Reasonably Significant: ▪ Clear presentation of data values and units Basic Practice: ▪ Appropriate layout, density and formatting of graph spaces, values and text

PART III Renal Outpatients Unit

Renal Outpatients Unit	
A doctor working in a renal outpatients unit is attending a patient with kidney disease who has been taking Irbesartan recently to reduce blood pressure. The doctor views the patient's blood pressure graph for the last couple of years, which suggests the patient has not been taking the medicine.	
High Level Tasks	▪ Read the current data values ▪ Compare the current data values with past readings ▪ Check if the current data values fail to exceed or fall below a threshold ▪ Check for significant patterns over time in a series of data values
Potential Risks	High: ▪ Doctor fails to recognise that the data is now showing a new trend: ▪ Fails to see that trend ▪ Doctor fails to recognise the previous trend ▪ Doctor fails to recognise the differences between the two trends ▪ Doctor fails to understand that the change in trend is significant Medium: ▪ Doctor fails to recognise where the patient's current blood pressure readings are in relation to the target range Low: ▪ Doctor fails to accurately read the patient's current blood pressure reading Possible consequence of risks: Incorrect treatment
Key Feature Areas	Most Significant: ▪ Viewing trends and interactions, including interpolation ▪ Clear and appropriate axes Quite Significant: ▪ Viewing data values in relation to normal ranges, targets and thresholds ▪ Intuitive and appropriate scaling Reasonably Significant: ▪ Support for baseline deviation calculations Basic Practice: ▪ Clear presentation of data values and units ▪ Appropriate layout, density and formatting of graph spaces, values and text

PART IV Inpatient Monitoring

Inpatient Monitoring	
Variation 1: A nurse has been called to see an elderly inpatient who is very drowsy. The nurse views the patient's chart and sees that the patient's blood pressure has increased dramatically since the last set of readings, whereas their oxygen saturations have fallen. The nurse suspects a possible intracranial bleed. Variation 2: An inpatient on a ward is complaining of a severe headache and nausea and the nurse increases the observation schedule from 4 hourly to every 15 minutes. On the second reading the nurse finds the blood pressure is increasing with an increased pulse rate and informs the doctor who then reviews the last day's observations with the current ones.	
High Level Tasks	▪ Read the current data values ▪ Compare the current data values with past readings ▪ Check if the current data values fail to exceed or fall below a threshold ▪ Check for significant patterns over time in a series of data values ▪ Check for significant interactions between data series

Potential Risks	High:
	▪ Nurse fails to see the increase in blood pressure
	▪ Nurse fails to see the drop in oxygen saturations
	▪ Nurse fails to see the rise in blood pressure and drop in oxygen saturations as significant:
	  ▪ Fails to see how much the readings have risen/dropped
	  ▪ Fails to see how quickly the readings have risen/dropped
	▪ Patient fails to understand the new trend in their blood pressure readings
	Medium:
	▪ Nurse fails to see the changes in blood pressure and oxygen saturations in relation to each other
	Possible consequence of risks: Delayed diagnosis/ understanding of problem

Key Feature Areas	Most Significant: ▪ Viewing trends and interactions, including interpolation ▪ Simultaneous views of multiple data series ▪ Intuitive and appropriate scaling Quite Significant: ▪ Clear and appropriate axes Reasonably Significant: ▪ Support for baseline deviation calculations Basic Practice: ▪ Clear presentation of data values and units ▪ Appropriate layout, density and formatting of graph spaces, values and text

PART V Hypertension Clinic

Hypertension Clinic	
A GP is seeing a patient who is being treated for hypertension. The GP checks the patient's blood pressure and looks at their readings, which have been taken approximately every three months over the past three years. For the last six months the patient has been taking a new regime of anti-hypertensive drugs. The GP checks that the patient's blood pressure is still within the target range, which it is, and that it is stable.	
High Level Tasks	▪ Read the current data values ▪ Check if the current data values fail to exceed or fall below a threshold ▪ Check for significant patterns over time in a series of data values
Potential Risks	High: ▪ GP fails to see that the blood pressure has stabilised ▪ GP fails to see that the patient's blood pressure readings are in the target range Medium: ▪ Patient fails to understand the trend in their blood pressure readings Possible consequence of risks: Incorrect treatment
Key Feature Areas	Most Significant: ▪ Viewing trends and interactions, including interpolation ▪ Viewing data values in relation to normal ranges, targets and thresholds Quite Significant: ▪ Intuitive and appropriate scaling ▪ Clear and appropriate axes Reasonably Significant: ▪ Clear presentation of data values and units Basic Practice: ▪ Appropriate layout, density and formatting of graph spaces, values and text

REVISION AND SIGNOFF SHEET

Change Record

Date	Author	Version	Change Reference
15-Jul-2008	Ben Luff	0.0.0.1	Initial draft for review/discussion
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18-Jul-2008	Mick Harney	0.0.2.0	First copyedit pass and raise to Working Baseline #2
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Document Status has the following meaning:

- **Drafts 0.0.0.X** – Draft document reviewed by the Microsoft CUI Project team and the Authority designate for the appropriate Project. The document is liable to change.
- **Working Baseline 0.0.X.0** – The document has reached the end of the review phase and may only have minor changes. The document will be submitted to the Authority CUI Project team for wider review by stakeholders, ensuring buy-in and to assist in communication.
- **Baseline Candidate 0.X.0.0** – The document has reached the end of the review phase and it is ready to be frozen on formal agreement between the Authority and the Company
- **Baseline X.0.0.0** – The document has been formally agreed between the Authority and the Company

Note that minor updates or corrections to a document may lead to multiple versions at a particular status.

Open Issues Summary

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Audience

The audience for this document includes:

- **Authority CUI Manager / Project Sponsor**. Overall project manager and sponsor for the NHS CUI project within the Authority.
- **Authority Clinical Applications and Patient Safety Project Project Manager.** Responsible for ongoing management and administration of the Project.
- **The Authority Project Team**. This document defines the approach to be taken during this assessment and therefore must be agreed by the Authority.
- **Microsoft NHS CUI Team**. This document defines the approach to be taken during this assessment, including a redefinition of the Clinical Applications and Patient Safety Project strategy.

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