8 Types of Information

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8.1 Introduction

The research problem emanating research questions, hypotheses, and aim and objectives of a research study primarily drives the subsequent research design and methods that a researcher would utilise to conduct a particular study. In turn, these aspects of a research process and study determine the type of information that needs to be gathered in order for a researcher to meet the underpinning objectives and aim, as well as answer the research questions and hypotheses of a study. To this end, researchers use various types of information, in a multitude of ways, to find and present answers to their research questions.

An exposition of common information types that are utilised in diagnostic imaging and radiotherapy research is presented in this chapter. The discussion covers three categories: literature, quantitative and qualitative information. The focus in this chapter is twofold: to describe the types of information and to provide some insights on when and how to use the information.

8.2 Literature

Researchers continuously need information to formulate research problems or find answers to research questions. Literature can fulfil both of these in a variety of ways. Literature refers to the plethora of sources that exist in various media: for example, digital, print, artefacts, images, text and audio recordings, related to a

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A. Ramlaul (ed.), *Medical Imaging and Radiotherapy Research: Skills and Strategies*, https://doi.org/10.1007/978-3-030-37944-5_8

topic of interest [1]. Research literature can be defined as the current available body of knowledge, made up of publications in various formats (for example, original research articles, opinion papers, editorials, legal documents, blogs, tweets and videos) related to a specific research problem of interest. This set of literature includes current theories, hypotheses, practices, evidence and recommendations for further research pertaining to the research area of interest [2]. Furthermore, literature also sets the scene for one's quest for knowledge to ultimately inform theory and practice in diagnostic imaging and radiotherapy [2, 3]. In scientific research literature can be used as a literature review or a literature control.

8.2.1 Literature Review

A literature review entails activities and processes of searching, identifying, recording, understanding, sense-making, evaluating and synthesising what is already known on a topic or subject of interest, and then presenting it in a manner that can be understood by the diagnostic imaging and radiotherapy community, as well as the broader scientific community [3, 4]. It can also be seen as an end product of a research study because it often entails various decisions and justifications by researchers regarding the inclusion of particular research literature opposed to other research literature, for example, or the specific presentation of the current status of the existing knowledge and debates on the area of interest [3]. A literature review has the following functions [1, 3–5].

- It provides a theoretical background and justification for a study to be conducted and facilitates focussing on and clarification of a research problem.
- It broadens researchers' knowledge based in their chosen subject of study.
- It provides a researcher with information on research design and methodology to follow.
- It assists a researcher to develop a theoretical or conceptual framework for a proposed study.
- It situates and contextualises a proposed study's significance in relation to what already exists.
- It enables a researcher to integrate and demonstrate how a conducted study advances the corpus of knowledge within a specific discipline.

Depending on the purpose of a study a researcher wants to conduct, a literature review can take on one of two major formats. The presentation can be in a narrative or systematic format. A narrative literature review commonly forms the introduction and/or background to research reports; it can also be a standalone product. In contrast, systematic literature reviews are research studies on their own. They are a standalone product, but can also form part of a bigger research study [3]. Table 8.1 provides an overview of the main characteristics of each literature review type [3, 6, 7].

Table 8.1 Characteristics of the two main formats of a literature review

Characteristic	Narrative literature review	Systematic literature review
Purpose	• Summarises and critiques the existing body of knowledge to provide a broad overview of what is already known on the topic of interest • Provides a background to a research problem to be studied	• Summarises and critiques existing literature on a topic of interest, by integrating either quantitative or qualitative data or both, to address a specific research question by following meticulous, rigorous methods that are spelled out in advance
Stance	• Reflexive, subjective and interpretive	• Neutral, objective and aggregative/ translative
Literature inclusion	• Non-exhaustive, and only a sample of literature is used • No explicit inclusion/ exclusion criteria • No formal critical appraisal of literature and therefore no inter-rater agreement	• Use all literature that exist in relation to the research question • Explicit inclusion/exclusion criteria • Formal critical appraisal of literature is done, and the final appraisal is subject to inter-rater agreement
Methodology	• No exact methodology is followed; the process is therefore iterative	• A precise methodology is followed with regard to research question formulation, literature search strategy and reporting of findings. Thus, the process is more linear
Sense-making of literature	• Inductive reasoning is used to interpret the literature and extract meaning	• Deductive or abductive reasoning is used to interpret and extract meaning from the literature
Rigour	• Less rigorous	• More rigorous
Variations	• General review • Theoretical review • Methodological review • Historical review	• Narrative systematic review • Meta-analysis • Meta-summary • Meta-synthesis • Rapid review • Integrative literature review

8.2.2 Literature Control

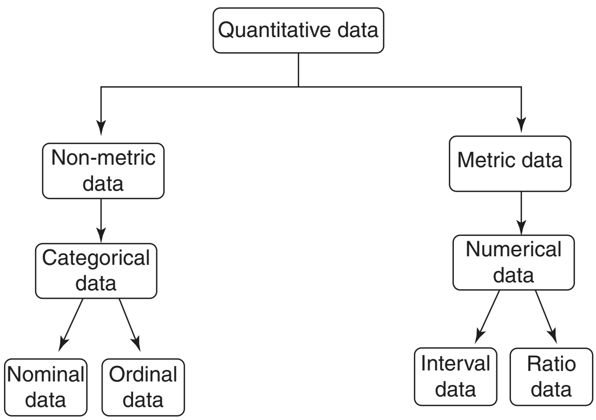
Literature control is used as a premise of departure to which one can compare and contrast one's results or findings to demonstrate the significance of one's study in relation to the existing body of knowledge in the field [8]. It locates a researcher's study findings within the existing body of knowledge to demonstrate how the findings contribute, further develop, negate or challenge the current state of knowledge related to the topic of interest [9]. It can be used to provide readers with an insight into how a researcher conceptualised a specific research issue, interpreted the research findings or chose a particular research instrument [10]. One would typically use literature control in the discussion section of a research report, thesis or journal article. For example, a researcher would discuss how a study contributes to the advancement of knowledge, theory and practice in diagnostic imaging and radiotherapy.

Diagnostic imaging and radiotherapy theory and practice cannot only be advanced with existing evidence. Therefore, there is a continuous need to explore new avenues within the profession to inform evidence-based practice. Researchers design and conduct a variety of research studies that produce and make use of quantitative or qualitative information, or both information types. Quantitative and qualitative information is explored below. Some of the relevant types used in medical imaging and radiotherapy research are presented.

8.3 Quantitative Information

Quantitative information is the final presentation after quantitative data have been interpreted and organised in a meaningful manner. Data are generally considered quantitative if they are numerical in nature. Researchers can use participant observation, surveys/questionnaires (digital, hardcopy, face-to-face, telephonic, self-reported) or experimental techniques to obtain quantitative data. These methods of data collection can consist of closed or open-ended questions, or a mixture of both. The data are interpreted in a rigid manner through statistical analysis, to either describe the characteristics of the sample/population or to make inferences (see Chap. 15). By implication, quantitative studies usually make use of large sample sizes in order to be representative of a target population. The types of data thus collected relate to measurements, scores or counts, for example [11]. Quantitative data are classified in several ways based on the amount or characteristics of the information as shown in Fig. 8.1. Data can be categorised in four levels: nominal, ordinal, interval and ratio. Nominal data provide the least amount of information and ratio data the most. These four levels can be further classified into categorical and numerical data, and even further into non-metric and metric data [12]. Let us have closer look at each of the four data levels in greater detail.

Fig. 8.1 Classification of quantitative data



8.3.1 Nominal Data

Nominal data classify or name information into categories or groups, as opposed to measuring the data. Values can be distinguished from one another by different names. A nominal scale usually has two or more classes or categories. When using nominal scales, a researcher allocates a category or class with identical features with an identical numerical value [11–13]. For example, if a researcher is collecting data by means of a questionnaire with regard to the gender of patients visiting a radiotherapy department then it will be necessary to list three options: male, female, other (please specify). During the data analysis stage a researcher would then code each of these categories numerically: male 1, female 2 and other (please specify) 3. These numerical codes would then be subjected to statistical analyses so that a researcher can then interpret and present the findings regarding the gender of patients visiting the particular radiotherapy department. Other examples of categories in this data type are marital status, tribe and even feelings. One aspect to remember is that the categories or classes of nominal data are usually mutually exclusive and there is ordinarily no order or ranking; comparisons between categories are thus not possible as they are qualitatively dissimilar [11, 12]. By implication, the questions are therefore close-ended.

8.3.2 Ordinal Data

Ordinal data allow for mutually exclusive classes or categories to be arranged in some rank order. This allows for comparisons between variables. Researchers can compare the differences in intensity or magnitude to find out whether two values of a variable are equal, lesser than or greater than the other. Surveys usually use Likert scales when working with ordinal data to group the numerical values together for a particular category. The use of a Likert scale (e.g., 5-point Likert scale or 7-point Likert scale) allows a researcher to obtain the degree of agreement of a respondent with statements in a questionnaire [11–13]. If a researcher wants to find out how satisfied a patient was with the level of care provided during a contrast medium examination in a particular radiology department by the radiographers, then use could be made of a 5-point Likert scale as shown in Table 8.2.

Respondents should mark the most appropriate answer based on their experience or opinion. Other examples of ordinal types of data include levels of education, levels of distress, ranking radiographic images in order of resolution from lowest to highest, or the level of importance a radiotherapist attaches to a particular professional skill attribute. The questions asked are usually closed-ended in nature.

Table 8.2 Example of an ordinal data type question

The level of care that radiographers provided me during my contrast medium examination was				
1	2	3	4	5
Very poor	*Poor*	*Satisfactory*	*Good*	*Very good*

8.3.3 Interval Data

Interval data allow for numerical measurements to differentiate between magnitude and quantity between different values of a variable. The units of measure are also always equal for all values attached to a variable; definite conclusions can therefore be made between the differences between value points in close-ended questions [11–13]. Examples of interval data could be the following.

- The temperature of an X-ray unit at a specific time
- The number of hours that a radiographer spends completing a particular quality control test in five general X-ray rooms
- The emotional intelligence quotient of first year radiography students
- Radiation dose
- Body mass index (BMI)
- Blood pressure

Another example could be the number of days that a patient had diarrhoea following radiotherapy treatment to the pelvic area. To obtain relevant data a researcher could include a question to determine when a patient had diarrhoea as shown in Table 8.3.

The range of options to select interval data are useful when a researcher aims to investigate any sort of relationship between variables or test a hypothesis. Interval data are commonly used in experimental studies where a researcher may want to assess the effect of kilovoltage peak (kVp) on the temperature of the anode of an X-ray tube. The kVp is then altered and the different anode temperatures noted for each kVp setting. The kVp will be the independent variable; the anode temperature will be the dependent variable. Depending on the hypothesis to be tested, the tabulated data of kVp values versus anode temperature can then be subjected to statistical analyses to establish whether the null hypothesis should be accepted or rejected.

8.3.4 Ratio Data

A ratio data scale has a true zero value. It is unique compared to the other three data types discussed above. A zero value represents the absence of the particular measurement that a variable measures. Ratio scales have equal intervals and magnitude properties. This means one should be able to assume that two units on a scale

Table 8.3 Example of an interval data type question

Following my radiaton treatment session to my pelvic area I had diarrhoea for:

☐ 1 day
☐ 2 days
☐ 3 days
☐ 4 days

represent twice the distance of one unit. Put differently, if one unit represents 10 m, then two units would represent 20 m (10 m × 2 = 20 m). Examples of ratio data and scales include physical measurements of weight (mass), length, time, volume, distance and angles [11–13]. Ratio data can be used in a similar fashion to interval data with regard to establishing relationships, associations and differences.

8.3.5 Literacy and Language Barriers and Obtaining Appropriate Data

Sometimes researchers are faced with the challenge to ensure that the data that they obtain are accurate, but the respondents may have differing levels of literacy or a language barrier may exist. From personal experience, using visual cues in a questionnaire, or survey, may assist in alleviating and countering this challenge. For example, if you want to obtain information about the respondents' biological sex or level of satisfaction with a service that received, you may formulate the questions as displayed in Table 8.4.

8.3.6 Quantitative Data Analysis and Display

When the required data have been collected by a researcher then this is followed by data interpretation/analysis. This is required to present the information in a meaningful manner. This depends on the information available and the intended audience.

8.3.6.1 Data Analysis

Researchers make sense of quantitative data by using a variety of statistical analyses for interpretation of such data [7, 13, 14]. However, an in-depth exploration of data analysis is beyond the scope of this chapter.

Use is made of flowcharts in Figs. 8.2, 8.3 and 8.4 to depict the next step of the research process after data collection. The purpose of a research study should inform

Table 8.4 Example of formulating questions to address literacy and language barriers

1. Indicate your biological sex.

2. Indicate how you feel about the service you received today.

Satisfied Undecided Dissatisfied

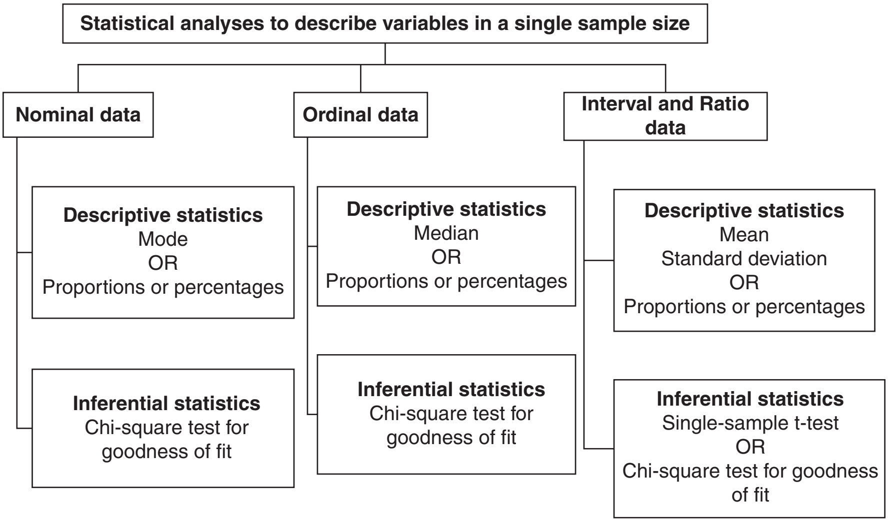


Fig. 8.2 Describing a single sample size with statistics

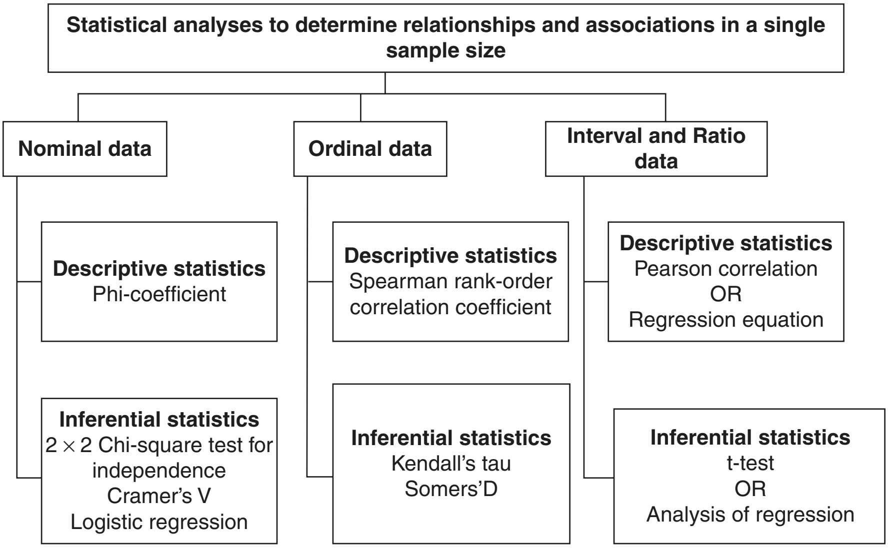


Fig. 8.3 Determining relationships or associations in a single sample size with statistics

the decisions made regarding the appropriate statistical techniques used for analysis. Figure 8.2 demonstrates the decisions of a researcher to describe variables in a study in a single sample size: one score per respondent per variable. Figure 8.3 demonstrates the statistical techniques that can be utilised when relationships or associations need to be established from a single sample size where two variables

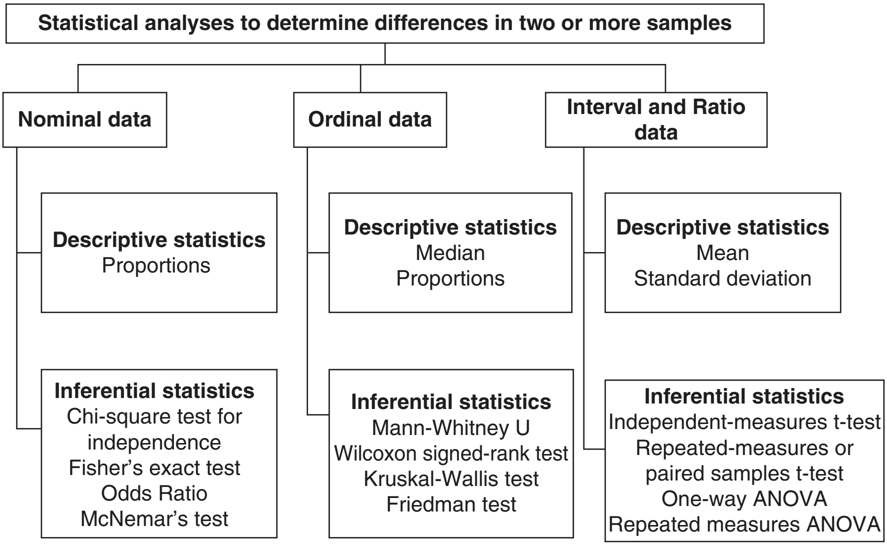


Fig. 8.4 Determining differences in two or more sample sizes with statistics

are measured for each respondent. Figure 8.4 portrays the statistical analyses that can be done to determine the differences between groups of variables for two or more different sample sizes.

8.3.6.2 Data Display

Data display involves a process of organising raw data into comprehensible and unambiguous information so that an intended audience or readership can understand the results. The choice of presenting the organised data for interpretation depends on whether one is dealing with discrete or continuous data.

Discrete data can be counted. A researcher thus needs to determine distribution frequencies for each category of a particular variable being measured. This can also subsequently be presented in distribution frequency tables, bar graphs or pie charts. Data that fall within the discrete data realm are nominal and ordinal data [2].

The use of distribution frequency tables allows a reader to see how many cases fall into a particular category. If a bar graph is used a reader can determine the number of cases in each category by looking at the height of the bar and with which value it intercepts on the y axis. A pie chart can be used to demonstrate the proportions relative to the number of cases that make up each category for a particular variable. These points are illustrated in the following example.

- A researcher is interested in determining how many patients, by sex, have undergone chest radiography at a public hospital for a period of 7 days. Using the patient register, the following information was obtained (M = male; F = female): M F M M M F F F F F F F F M M M M M M F F F F.

Table 8.5 Frequency distribution of patients undergoing chest radiography for 7 days

Sex	Frequency (f)
Male (M)	10
Female (F)	13
Total (n)	23

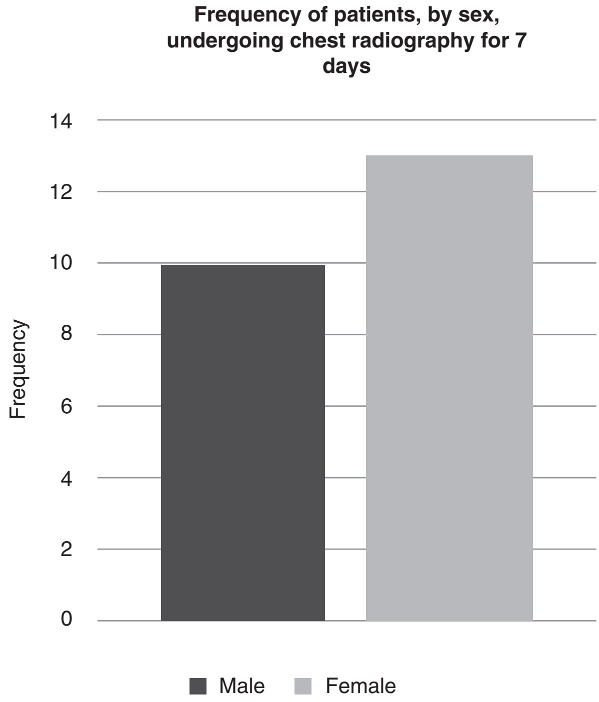


Fig. 8.5 Bar graph

Table 8.5 illustrates presentation of the data in a distribution frequency table. The numerical data may be presented in bar graph (Fig. 8.5) or a pie chart (Fig. 8.6).

Continuous data produce real numbers and can be processed by standard mathematical rules [2]. Interval and ratio data are categorised. Similar to discrete data, a researcher could display this information by means of grouped distribution frequency tables or graphically by means of histograms, frequency polygons, line graphs or scatter plots.

One could group the number of radiographic images rejected as part of a quality audit of hospitals in a particular district. If there are ten hospitals in the district where the audit was being conducted, then a grouped distribution frequency table may look like the one represented by Table 8.6. The grouped distribution frequencies could be used to compile a frequency polygon. By looking at the information in Fig. 8.7 a reader should be able to understand frequency of the unplotted values. The trend of the number of patients visiting a department over a period of one year, for example, can be represented in a line graph (Fig. 8.8). A reader should be able to see that the most patients were seen in the department during

Fig. 8.6 Pie chart

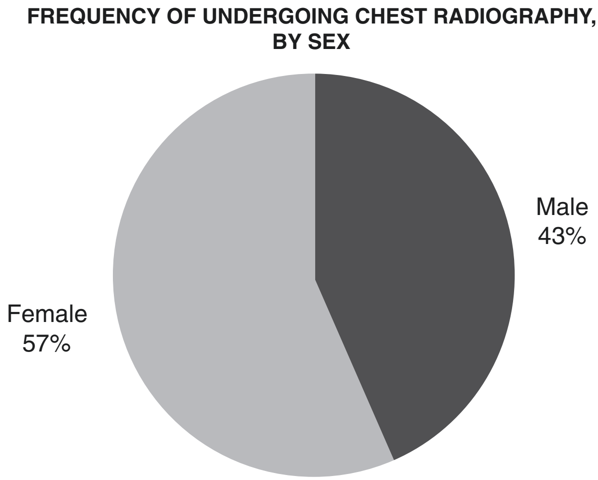
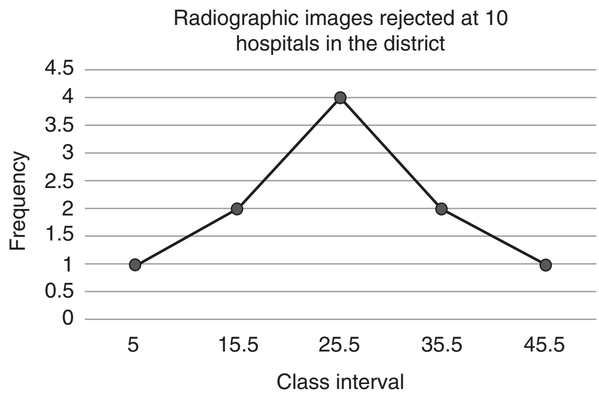


Table 8.6 Grouped frequency table

Class interval	Frequency (*f*)
0–10	1
11–20	2
21–30	4
31–40	2
41–50	1
Total (*n*)	10

Fig. 8.7 Frequency polygon



December, and the least during March 2018. Histograms can be used to represent continuous data; they look similar to bar graphs except that the bars touch one another. Similar to the bar graphs the height of the bar represents the frequency of cases in each category or class interval. When a relationship between two variables needs to be graphically depicted, a scatter plot would be meaningful as demonstrated in Fig. 8.9.

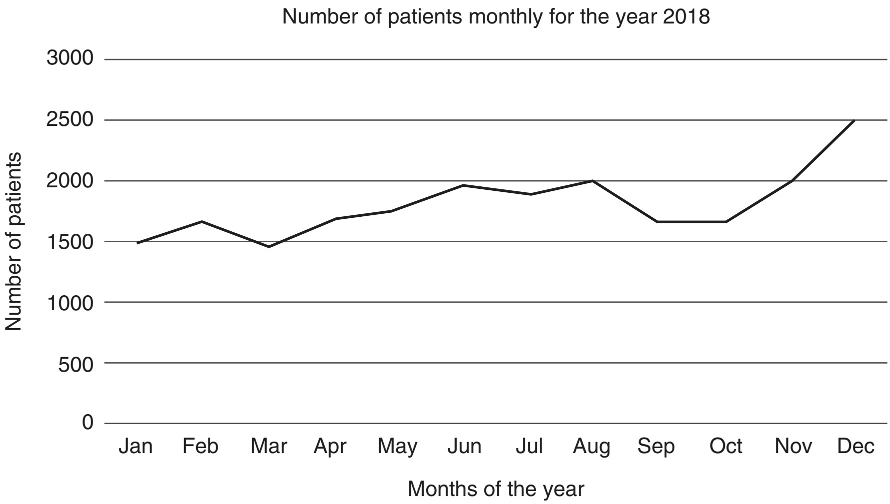


Fig. 8.8 Line graph

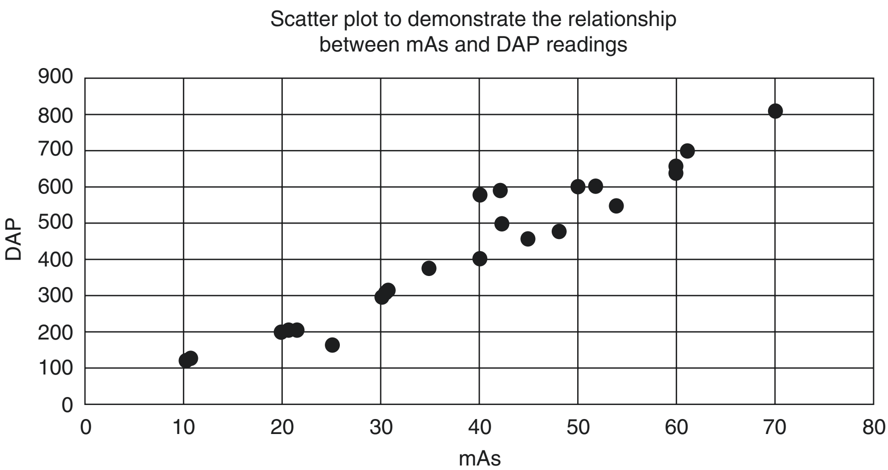


Fig. 8.9 Scatter plot

8.3.7 Accuracy, Specificity, Sensitivity

Establishing the performance of radiographers' image interpretation abilities is well covered in diagnostic imaging research. With the establishment of and continuous research into radiographer-led image interpretation practices and the effect of education and training, researchers may be interested to determine participants' performance regarding accuracy, specificity and sensitivity pertaining to image interpretation.

When applied in this context, researchers basically want to determine radiographers' ability to distinguish between normal and abnormal radiographic images. The radiographers' decisions or responses may be classified as follows.

- Correctly interpret a radiographic image as abnormal (true positive).
- Correctly interpret a radiographic image as normal (true negative).
- Incorrectly interpret a radiographic image as abnormal (false positive).
- Incorrectly interpret a radiographic image as normal (false negative).

Using these responses, the sensitivity, specificity and accuracy of radiographers' image interpretation ability can then be calculated [15–19]. This information can also be represented graphically using the receiver-operator characteristic (ROC) curve (Fig. 8.10). The closer the curve is to the upper left corner, the higher the accuracy of a radiographer with regard to discriminating between normal and abnormal radiographic images. The scale used for both the y and x axes usually ranges between 0 and 1. The greater the area is under the curve (AUC), the better a radiographer's accuracy. These measures can also be used to determine the performance of different imaging modalities in a department or different procedures [16, 20–22].

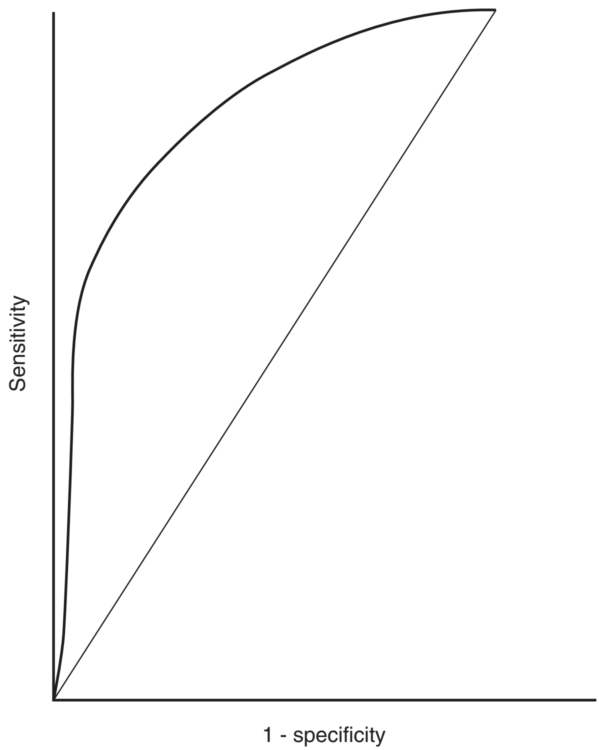


Fig. 8.10 An example of the characteristic shape of the ROC curve

8.4 Qualitative Information

The other side of the coin, relative to quantitative information, is qualitative information (see Chap. 16). This is sourced, documented, interpreted, organised and presented in a totally different manner. Raw qualitative data can be utterances of individuals, written narratives, visual artefacts (digital or physical) or audio recordings, for example. Researchers obtain this kind of data through unstructured, semi-structured or structured interviews; reflective journaling; visual methodologies; and observations [23]. The aim of qualitative studies is to understand phenomena as they occur in their natural setting and how individuals make sense of their experiences or context they find themselves in [23, 24]. Examples of qualitative topics may include: the lived experiences of therapeutic radiographers regarding workplace bullying; the particular culture in a diagnostic radiography department; or the manner in which undergraduate diagnostic radiography students experience and cope with death and dying during clinical placements. Looking at these examples one can see that they deal with rather specific and sensitive information. The elicitation of appropriate and rigorous information is imperative to ensure credible findings in the end to inform the theory and practice of diagnostic imaging and radiotherapy. Hence, data gathering methods alter depending on the focus of a research study to be conducted. Table 8.7 provides common research purposes and the appropriate qualitative data gathering approach to use as well as research designs [23].

Qualitative data need to be recorded in appropriate ways in preparation for analysis and interpretation. Recording can be done by transcriptions on paper, audiovisual recordings or photographs/collages/sketches and the like. During the analysis and interpretation phases of working with qualitative data and information, researchers need to go about this in a systematic manner in order to hold scientific grounding and to ensure trustworthiness of the information presented at the end of a research process.

Table 8.7 Research study aims and corresponding data gathering technique and research design

Research study aim/purpose	Data gathering approach	Research design
Understanding the culture or a group of people	Participant observation Document analysis Interviewing	Ethnography Grounded theory
Gaining insights into converging or diverging perspectives on a particular topic especially when exposure of participants to various perspectives are crucial to the study	Focus groups	Explorative-descriptive
Understanding a phenomenon from individual perspectives or the lived experiences of individuals	Individuals interviewing	Phenomenology Explorative-descriptive Case study

Data analysis in qualitative studies starts with coding. The process of coding entails, for example, a researcher reading all the interview transcripts generated and then assigning a meaningful unit to a segment of the transcript to capture the meaning thereof. This is done for all transcripts. Thereafter, this initial set of codes generated during this first cycle of coding is clustered into code families or groups. A researcher then assigns the code of this newly formed group of codes to the respective segments of the transcripts or keeps a thorough list of the codes clustered in the particular group. This clustering continues to form categories by way of further reducing the code groups or families. These categories are then further refined to form themes and sub-themes. In the final research report, it is then the themes and sub-themes that are discussed. A theme and sub-theme abstractly capture the participants' experiences. For example, workplace bullying in a radiotherapy department and the various manifestations related to the experiences [8]. The content of each theme and sub-theme is formed by the categories based on the data. This is known as a thematic synthesis or thematic analysis based on the content of the data, which is the most commonly used method in diagnostic imaging and radiotherapy research [6, 8, 25]. The main factor, in the data analysis process, is the research question underpinning a study. It is easy to go astray when analysing and interpreting data. Analyses and interpretations pertinent to the research questions should be the focus and included in the final presentation of the information. One can therefore appreciate that data analysis works in a reductionist fashion to make sense of the data. This allows a researcher to present data in a meaningful manner for the readers (see Fig. 8.11). The presentation of qualitative information is done in a descriptive and narrative format. Extracts from the data sources are used as substantiating evidence for the narrative or description provided. The same procedure can

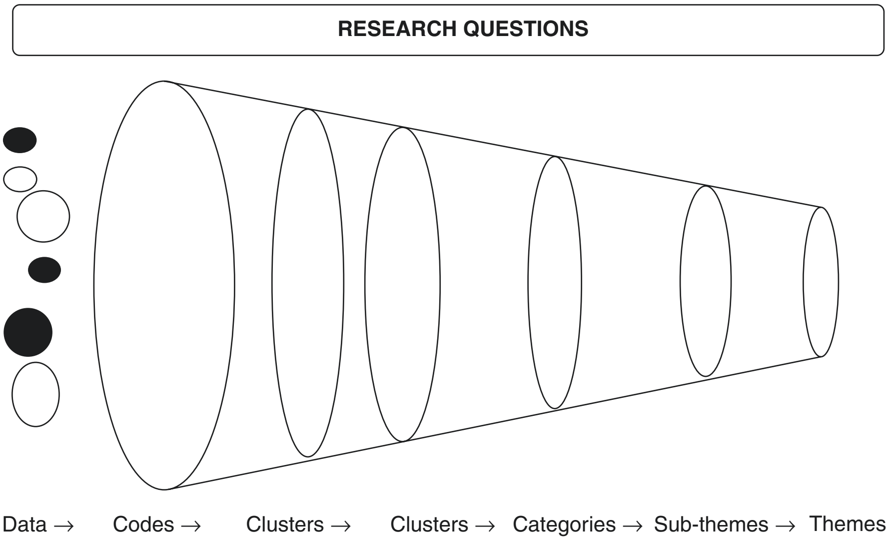


Fig. 8.11 Data reduction from data to themes underpinned by the research questions

be followed using computer-assisted qualitative data analysis software (CAQDAS) like ATLAS.ti and NVIVO [8].

A trend in qualitative research is the use of visual methodologies. An in-depth exposition of this methodology is beyond the scope of this chapter. Nonetheless an introduction to this field is deemed necessary.

8.4.1 Visual Methodologies

Visual methodology is an umbrella term for social sciences methods that use arts-based techniques to generate and represent knowledge. These methods are often used for topics where participants are required to think differently about a topic or subject and where they have to represent the unconscious mind in a conscious manner. Some people can also represent their ideas and experiences better in a visual manner opposed to in the written or spoken word. Particular methods included under visual methodologies are naïve (unplanned) sketching, photo-voice, photo-elicitation, collages, video, sculpture (for example, Mmogo-method™).

The use of visual artefacts as elicitation or transmittal media allows participants, during variations of interviewing or focus groups, to verbalise their viewpoints on the topic at hand. For example, the author personally used the Mmogo-method™ as a transmittal medium in a study to understand undergraduate diagnostic radiography students' experiences and coping with death and dying in the workplace. Another example where visual methodology may be useful is in studies focussing on resilience.

Visual methodologies almost always are combined with other forms of data gathering whether it is written text or spoken words. Visual methods add another dimension to qualitative information that is otherwise unattainable and enhance data richness [26, 27].

8.5 Conclusion

Data need to be sourced using appropriate methods/techniques. Collected data in academic writing are recorded, analysed, interpreted, organised and then presented as meaningful information to the readers. What is deemed appropriate is dependent on the approach to research that researchers take and the underpinning research questions of a study. An overview of common data and information, including visual methodologies, used in diagnostic imaging and radiotherapy, was covered in this chapter. The examples and discussion are by no means an exhaustive body of literature. The information used in research is grouped into three classes: literature, quantitative and qualitative information. The type of information that a researcher ends up with should be guided by the purpose of the study; there is no one size fits all. A clearly formulate research problem, research question(s), aim and objectives are crucial for any research study.

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