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Aim and scope

The Malta Journal of Health Sciences is a peer-reviewed, open access publication that promotes the sharing and exchange of knowledge in Health Sciences. It provides a platform for novice and established researchers to share their findings, insights and views within an inter-professional context. The Journal originates within the Faculty of Health Sciences, University of Malta.

The Malta Journal of Health Sciences disseminates research on a broad range of allied health disciplines. It publishes original research papers, review articles, short communications, commentaries, letters to the editor and book reviews. The readership of the journal consists of academics, practitioners and trainee health professionals across the disciplines of Applied Biomedical Science, Audiology, Communication Therapy, Community Nursing, Environmental Health, Food Science, Health Services Management, Medical Physics, Mental Health, Midwifery, Nursing, Occupational Therapy, Physiotherapy, Podiatry and Radiography.

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Guest editorial

HIGHER EDUCATION AND THE HEALTH CARE PROFESSIONS

Joseph Cacciottolo

Pro-Rector for Academic Affairs, University of Malta, Msida, Malta

The landscape of health care in Malta is in a rapid state of flux, as indeed are the metrics for gauging its profile, diversity and effectiveness. Changes over time are only partly explained by demographic shifts, advisability, and political expediency; agents of change also include the demands from the large segment of the population that increasingly looks at scientific solutions to its health problems, as well as others who seek alternative remedies and practices.

The changing landscape relating to health is also due in part to the increasing and multicultural variations both within the Maltese population, as well as in relation to the influx of persons coming from culturally diverse societies, both within and beyond the Member States of the European Union.

Change is also influenced by demands of people who have easy and rapid access to all manner of medical information, ranging from that which is accurate, to the potentially misleading. Increasing demands from the community at times present a quandary as they may not coincide well with objective health-related needs, capacities for their fulfilment, and fiscal considerations.

The role of Universities as purveyors of health-related education is also changing, from a position of historically assured primacy, to that of acknowledged leadership in our communities. This implies respect, partnership, as well as more practical relevance within communities, allowing for flexibility and quicker response to societal needs.

Higher education and formation of health care professionals need to be sensitive to changes, and rapidly refine, define and develop curricula in response to change, while preserving academic rigour. Newly qualified health care professionals need to have the knowledge and transferable skills that would enable them to function competently in increasingly complex settings, in challenging environments, and often in uncertainty.

It is often of concern that our teaching strategies, at all levels, as well as our curricula, may be moving at paces slower than the progress of scientific discovery and fast technological development. This may be due to resistance to change, which is in turn due to several factors, among which may be feelings of anxiety, inertia, and self-interest, as well as the fallacy of assuming singularity and exception.

The value of higher education as a direct conduit to employability at the right level is increasingly recognised across all disciplines, and is indeed a powerful index of

successful teaching programmes. With specific regard to the education of professions that deliver health care, functionality, application and practicality are crucial, and not merely desirable. Excellent communication skills underpin functionality, and specific educational approaches need to be utilised to enable students to learn and develop them in real-life settings, as in this regard, competences relate principally and directly to patient care, especially so with respect to vulnerable persons. The ability to communicate effectively is also necessary as part of the interpersonal skill-set required when dealing with all manner of colleagues.

Health care is increasingly being delivered by groups of professionals and it is essential that all those in training are conditioned at a very early stage to a team approach that cuts across traditional borders of disciplines. In many settings, be they academic or clinical, cross-functional teams are more effective, and the best are usually task-oriented and to a much lesser extent based on titles held, or presumed exceptionality of any discipline.

Inter-professional team training at undergraduate level has been shown to be effective in improving skills, communication and team knowledge, whatever the methodology used. Conversely, segregating students of the health professions during their education contributes to the fragmented culture of many health systems. The proximity of the teaching facilities at the University of Malta makes it possible to devise opportunities to bring together senior students in nursing, medicine, physiotherapy, pharmacy and other health care professions for joint learning experiences based on carefully devised scenarios.

In developed countries, the education and training of all health care professionals and in particular, medicine and dentistry, have been subjected to a much higher level of scrutiny as well as the insistence on outcome-based curricula, transparency, and accountability. There are historical and forensic reasons for these consequences, while one of the many positive outcomes has been the increase in partnerships with patients themselves, patients' organisations, and the public at large.

Developers of curricula for the health care professions are increasingly cognisant of the possible dehumanising effect of modern health care practice; a veritable paradox, when one considers the fast progress towards personalised medicine. It is therefore essential that the human element remains central to all health-related education. Evolving

curricula in all health-related spheres rightly insist on professional behaviour when interacting with patients; this involves honesty, integrity, concern for quality and empathy.

Students at all levels of professional training are rightly directed towards evidence and method-based approaches, propounded nearly 400 years ago by René Descartes. Yet, the focus on patient safety and dignity must be paramount: when teaching, in one's function as a role model, and especially so when delivering care.

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Review paper

MIXED METHODS RESEARCH IN THE HEALTH SCIENCES: A REVIEW

Luke Fiorini, Amanda Griffiths, Jonathan Houdmont

Division of Psychiatry and Applied Psychology, School of Medicine, University of Nottingham, United Kingdom

Abstract. This paper provides health science researchers new to mixed methods research with a review of the purpose of mixed method studies, an overview of the debate surrounding the method's philosophical underpinnings and a discussion of the most popular mixed method design classifications. It is argued that despite its limitations, mixed methods research has contributed to health science research, and allows researchers to profit from the benefits of combining quantitative and qualitative data in the same study while minimising their individual shortcomings. In so doing, researchers are able to answer complex real-world research questions typical of the health sciences. Additionally, it is argued that mixed methods research in the health sciences is best served by the paradigm of pragmatism and that while various mixed method typologies exist, the most popular classifications have common elements.

Keywords: mixed methods, research methods, health science, review, typology

1 Introduction

The term “mixed methods research” generally refers to studies that integrate both quantitative and qualitative research within a single investigation (Bryman, 2012). This methodological movement has emerged in opposition to the quantitative-qualitative dichotomy (Tashakkori & Newman, 2010) and as a result of the tensions that resulted from the paradigm wars instigated by proponents of these two methods (Cameron, 2009).

Mixed methods research features regularly within health science research (Östlund et al., 2011). As many health science issues are complex, mixed methods research allows researchers the opportunity to gain a greater, more meaningful understanding of such problems and answer questions that may have been less than fully answered

had quantitative or qualitative data alone been used (Halcomb & Hickman, 2015; Ozawa & Pongpirul, 2014). Despite this evident advantage, and the growing popularity of this research method, many researchers still hold back from employing it. O’Cathain, Nicholl and Murphy (2009) reported that a key barrier discouraging health science researchers is a lack of knowledge and training. They cite in particular a lack of education on the various mixed method design typologies and about the methods by which quantitative and qualitative information is integrated.

This article aims to provide individuals new to mixed methods research with an overview of (i) the recent history and purpose of mixed method studies, (ii) debates surrounding their philosophical underpinnings and (iii) a discussion of the most popular mixed method design typologies (classifications). The overall objective of the review is to familiarise the reader with the mixed method approach and facilitate an awareness of the types of complex health science research questions to which mixed methods can make a valuable contribution.

2 Methods

Papers were selected for inclusion in this *narrative review* (Grant & Booth, 2009) if they were published in English and dealt with mixed methods research and its application in the health sciences. The authors primarily used peer-reviewed journal papers; however, books, book chapters and documents by experts in the field were also utilised.

A broad search strategy was used to identify potential articles in order to identify as many relevant texts as possible. Several search engines, including PubMed, ScienceDirect, Ovid, Web of Science, PsycINFO, Google Scholar and the University of Malta’s HyDi were used. Google was used to identify books, book chapters and grey literature (other, non-commercial articles and information).

3 The Recent History and Purpose of Mixed Methods Research

Formerly known as “mixed research,” mixed method studies were initially carried out within cultural anthropology and fieldwork sociology (Johnson, Onwuegbuzie & Turner, 2007).

Correspondence to Luke Fiorini
 (luke.fiorini@um.edu.mt)

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Johnson et al. (2007) noted that Campbell and Friske (1959) formalised the concept of converging more than one research method in order to ensure that the explained variance was the result of the phenomenon being studied. This was later termed *triangulation* by Webb et al. (1966). During the 1970s and 80s, mixed methods continued to develop and challenged quantitative research which had dominated several fields, including health science, for several decades (Mertens et al., 2016). Amongst the important developments during this period, Denzin (1978) noted that triangulation could result in three outcomes: convergence, inconsistency and contradiction. Whichever of these outcomes prevailed, a superior explanation of the studied phenomena was achieved.

The method was further elaborated upon by Morse (1991), who proposed that combining qualitative and quantitative methods could greatly benefit health science research. The author suggested that data could be combined in two ways: data could be collected separately and then combined later during interpretation (simultaneous triangulation), or the results of one method could be used to plan the following method (sequential triangulation).

Mertens et al. (2016) noted that a book by Tashakkori and Teddlie (1998) on the topic of mixed methods research was a milestone in the development of the topic. The book brought together a summary of the early ideas and facilitated the development of the basic terminology of mixed methods research. This led to rapid acceptance and use of this research method.

In recent years, mixed methods research has been given various names and definitions. Following an analysis of 19 definitions of mixed methods research from prominent mixed method researchers, Johnson et al. (2007, p. 123) defined “mixed method research” as:

“... the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration.”

By means of standardising the information that is to be collected, quantitative methodologies are able to assess patterns across a large number of variables and infer causality. However, this standardisation limits the methodology’s ability to generate unexpected information and the reasons underpinning respondents’ answers (Bryman, 2012; Pasick et al., 2009; Scott et al., 2011). For example, armed with questionnaire data, Glover et al. (2005) were able to identify and quantify the causes of musculoskeletal injuries in over 3,000 physiotherapists. However, as is the case in such surveys, no data on related issues (as perceived by physiotherapists) which were not covered by the questionnaire, or knowledge on the nature and degree of influence of factors that informed responses, was available. For example, the survey found that only a negligible amount of injured physiotherapists used electrotherapy in place of manual techniques as a preventive strategy in response to

getting injured. No information on why this strategy was unpopular was reported, however. The opposite holds true for qualitative methodologies where standardisation is limited and information is typically collected from smaller samples. Qualitative research provides insights into participants’ underlying reasons for their answers, is richly nuanced and is open to the identification of unexpected processes (Bryman, 2012; Pasick et al., 2009; Scott et al., 2011). For example, this was highlighted in a study by Happell et al. (2013) whereby six exploratory focus groups allowed for the occupational stressors affecting 36 nurses to be identified. The generalisability of the findings, however, was limited.

By making use of both methodologies, mixed method data collection intentionally utilises the benefits of each methodology while minimising their limitations to best answer research questions (Creswell et al., 2003; 2011). This also allows a mixed method approach to address broad research questions and, by means of integrating findings acquired via contrasting methodologies, provides more robust and rigorous conclusions (Cronholm & Hjalmarsson, 2011). This is particularly relevant within health services research, where research questions can be complex due to the multi-factorial and holistic nature of health and illness and where there exists an established patient-centred multidisciplinary perspective (Glogowska, 2011). Quantitative and qualitative methodologies are thus combined within mixed methods research to achieve an understanding of a phenomenon that is greater than the sum of its parts (Scott et al., 2011).

A number of published texts have made the case for combining quantitative and qualitative research (Johnson et al., 2007). Examples include Sechrest and Sidani (1995), and later Collins, Onwuegbuzie and Sutton (2006). More recently, Tashakkori and Newman (2010) identified seven reasons often given for using mixed methods.

- (1) Complementarity – to integrate two different but connected answers to a research question: one reached via a quantitative approach and the other by means of a qualitative one.
- (2) Completeness – to gain a greater understanding of the phenomenon under investigation by merging qualitative and quantitative findings.
- (3) Development – to use the first phase of a study to obtain research questions, data sources or sampling frameworks for the second phase of a study.
- (4) Expansion – as in “development” but with the aim of elaborating on the information obtained in the first phase of a study.
- (5) Corroboration/confirmation – to determine the integrity of inferences attained from a strand of a study by means of integrated methods.
- (6) Compensation – to compensate for the weaknesses of one method via the strengths of the other.
- (7) Diversity – to compare and contrast divergent representations of the same phenomenon (as discussed later in the Dialectic approach).

While the advantages of utilising mixed methods are persuasive, the methodology has some limitations.

Johnson and Onwuegbuzie (2004) noted that due to a lack of resources, time and understanding, many researchers may find it difficult to undertake both quantitative and qualitative research, particularly if these are to take place concurrently. They are often more expensive to conduct because of the greater resources required to carry out both types of research and generally require more time to undertake (Zou, Sunindijo & Dainty, 2014). Issues also exist with the philosophical underpinnings of this methodology as well as research method typologies that guide it, criticisms that are covered in the following sections.

4 Philosophical Considerations in Mixed Methods Research

Although mixed methods research appears to offer a solution to the limitations of using quantitative or qualitative research methods in isolation, it has also received considerable criticism (Zou et al., 2014). Bryman (2012) identified two key arguments against the use of mixed methods research.

(i) The belief that research methods are embedded within commitments of what constitutes valid knowledge and how this can be obtained (epistemological commitments). The constructionist worldview, for example, which is generally linked with qualitative research methods, views reality as socially constructed by and between the people who experience it. Thus, while reality is independent of the individual, it is also viewed as subjective and need not be shared by others (Darlaston-Jones, 2007). On the other hand, in positivism, which is generally linked with quantitative research methods, reality is viewed as quantifiable, objective and universal. Reality is therefore considered the same for everybody and by means of the application of science, this shared reality can be identified and described (Darlaston-Jones, 2007).

(ii) The argument that quantitative and qualitative research are separate paradigms. For example, quantitative research emphasises that the researcher takes an impersonal role, tests theories (deductive approach), collects variables in a structured and validated manner, and obtains findings which can be generalised in order to describe numerically, predict and/or achieve causal explanations. Qualitative research, on the other hand, emphasises that the researcher takes a more personal role, generates theory (inductive approach), and collects words and images in an in-depth manner, in order to achieve a subjective description, exploration or an empathic understanding (Antwi & Hamza, 2015).

The criticisms, however, are open to debate as the concept that specific research methods carry fixed epistemological and ontological implications (about what constitutes reality and how individuals understand existence) is rebutted by the potential of each method to be used in a wide variety of research tasks. Morgan (2007) also highlighted how the term “paradigm,” originally coined by Kuhn (1970), is used inconsistently. Morgan (2007) identified at least four different categories of meaning for the term. These included: (i) a world view, (ii) an epistemological stance, (iii) shared beliefs among members of a speciality area, and (iv) model

examples of research. While the third category is closest to Kuhn’s (1970) view of a paradigm, and is the most common form used in scientific research, it has received little attention within discussions of social science methodology which tend to focus on the second category: a paradigm as an epistemological stance (Morgan, 2007). In contrast, Hall (2013) noted that it is the first category of meaning, paradigms as a world view, that was traditionally adopted by authorities on the topic of mixed methods research (e.g. Creswell & Plano Clark, 2007; Teddlie & Tashakkori, 2009), with stances being taken for each of ontology, epistemology, axiology and methodology. It is worth noting, however, that having discussed Morgan’s (2007) findings, Teddlie and Tashakkori (2010, p. 14) described a paradigm as a “shared belief in a research field”, noting that it reflected Morgan’s and Kuhn’s preferred definition. However, whilst Creswell (2011) acknowledged that some scholarly discussion was shifting from identifying one or more paradigms for mixed methods to focusing on paradigm use among members of a research field, he also asserted that the issue of the methodology’s philosophical underpinnings has to be acknowledged and tackled.

Four world views are commonly accepted: postpositivism (and positivism), which is linked to quantitative data collection methods and analysis; constructivism/interpretivism, which is most often aligned with qualitative data collection methods and analysis; the transformative world view; and pragmatism (MacKenzie & Knipe, 2006). In view of the seemingly incompatible paradigms underpinning them, mixed method researchers have struggled to find a common position in determining a rationale for combining quantitative and qualitative data (Hall, 2013). This has resulted in diverse philosophical positions being taken by different mixed method researchers (Creswell et al., 2011) and whilst constructivists are known to have made use of mixed methods (MacKenzie & Knipe, 2006), it is the latter two world views which have received most support.

The transformative paradigm arose to address issues of social inequalities, minority groups and social justice (Mertens, 2012) by means of bringing visibility to those who had been shunned to societal margins and by allowing them to be heard within the world of research (Mertens et al., 2010). The transformative paradigm contends that privilege and power influence all aspects of the research process (Mertens, 2007; Mertens et al., 2016), and that by means of the paradigm, contextual factors such as social justice, power and oppression are addressed in the type of research questions asked, the types of designs used, the manner in which they are used, and the kind of information gathered (Mertens et al., 2010). In view of the paradigm’s purpose, Mertens (2007, p. 219) suggested an “inclination” to use mixed methods as the methodology of choice and to consider the benefits of allowing community members to participate in data collection decisions.

Hall (2013), however, noted that as a paradigm for mixed methods, the narrow focus of the transformative world view limits its application to only certain types of social research. Additionally, Biddle and Schafft (2015) stated that the transformative paradigm is primarily focused on

ethics and values (axiology), with its central tenet being to prioritise the lives and experiences of the discriminated and oppressed in order to improve social justice, but it then provides less emphasis on ontology and is less equipped to provide guidance on methodology. The authors noted that the methodological imperatives of the transformative paradigm remained pragmatic in essence and thus question whether the transformative paradigm represents a different paradigm to pragmatism, or if it complements it by providing pragmatic researchers with axiological direction.

A pragmatic approach has been advocated by a number of researchers (e.g. Cameron, 2009; Cronholm & Hjalmarsson, 2011; Johnson et al., 2007; Morgan, 2007). Pragmatism values both objective and subjective knowledge, in terms of methodologies focusing on what “works” (Johnson & Onwuegbuzie, 2004; Morgan, 2007) and is oriented towards studying real world problems rather than the nature of knowledge (Hall, 2013). Pragmatism challenges claims by methodological purists that qualitative and quantitative methods represent two different worlds that cannot be integrated. Rather, in view of the different methods’ respective strengths and weaknesses, pragmatism views them as complementary (Cronholm & Hjalmarsson, 2011) and interdependent, with the ensuing advantages of mixing methods outweighing potential disadvantages (Scott et al., 2011).

The use of pragmatism within mixed methods research is not, however, without its critics. For example, Greene (2008) noted that work needs to be conducted to understand how the assumptions and stances of this paradigm influence enquiry decisions. Similarly, Hall (2013) cited the difficulty of determining the mixed methods design which “works” prior to using it. It is also worth noting that whilst pragmatism is mixed method researchers’ most popular single paradigm, several versions of it exist (Teddlie & Tashakkori, 2010).

While the discussion has so far dealt with the difficulty of accommodating both quantitative and qualitative research within the same paradigm, other approaches exist. Two alternatives include taking an a-paradigmatic stance or utilising a multiple paradigm approach (Hall, 2013). The first approach refers to overlooking the paradigm issue under the premise that methodology is unrelated to epistemology. Hall (2013), however, asserted that epistemology still contributes during interpretation of the gathered data, thus questioning the validity of this approach. Teddlie and Tashakkori (2010) identified three categories of the latter multiple paradigm option, which were labelled the complementary strength stance, the dialectical stance and the multiple paradigms stance. All three approaches highlight the benefit of utilising multiple paradigms to understand a phenomenon, but vary in their method of doing so.

The *complementary strength stance*, for instance, recommends keeping different methodologies as separate as possible to maintain and draw on the strength of the different paradigms (Morse et al., 2006). For example, Akinlua et al. (2016) conducted a systematic review of health care providers’ and lay individuals’ beliefs about hypertension. The authors identified articles which provided quantitative and qualitative data on the topic, analysed these separately

and only integrated the data within the discussion section of their study. A comparative study by Baldacchino and Bonello (2013a, b) on anxiety and depression among Maltese older adults in residential care homes in Malta and Australia also appears to fall under this category. Quantitative data on anxiety and depression levels were collected first. Subsequent face-to-face interviews then provided qualitative data that identified factors contributing towards residents’ anxiety and depression. The results of the two phases were then compared in the study’s discussion.

The *dialectical stance*, on the other hand, views paradigms as historical and social constructions and thus, while being valuable, they are not unalterable. Those who employ this stance consider opposing philosophical viewpoints and believe that the resulting tension created is beneficial (Greene, 2008). This stance was used, for example, by Nicca et al. (2012) who studied symptom management of individuals living with Human Immunodeficiency Virus (HIV). Qualitative data were initially gathered in order to form hypotheses which were then tested via quantitative data. As the researchers considered the HIV population to be a complex pluralistic society, a dialectic stance was applied, with a synthesis of the results developing from the tension caused by the gathered opposing viewpoints.

Finally, the *multiple paradigm stance* suggests that a researcher should choose the paradigm which is most appropriate given the research design being employed. For example, whilst post-positivism might take the lead in a sequential design which predominantly uses quantitative methods, interpretivism might be more fitting when a sequential design makes greater use of qualitative methods (Creswell et al., 2003).

It is thus evident that a multitude of philosophical positions have been taken by mixed method researchers and while pragmatism appears to be the most frequently cited stance, debate is ongoing. In fact, Bazeley (2004) commented that paradigmatic issues may remain unresolved due to the inability to research or prove paradigms. Mixed method health science research, however, is likely to be best served by a pragmatic world view as it focuses on the value and applicability of research to the real world and adopts the combination of diverse research strategies based on what works in practice (Creswell & Plano Clark, 2011; Lavelle, Vuk, & Barber, 2013).

5 Mixed Method Design Typologies

Design typologies feature regularly within the mixed method literature. Teddlie and Tashakkori (2010) provided four reasons for this: (i) they establish a common language within the mixed method field, (ii) they provide interested researchers with blueprints, (iii) by introducing designs that are dissimilar from those in qualitative or quantitative research, they legitimise mixed methods research, and (iv) they are of value for pedagogical reasons. Numerous such typologies exist and their development is ongoing. This section thus does not aim to be definitive and instead, two of the more frequently used typologies will be discussed.

Tashakkori and Newman (2010) suggested that mixed method designs can be divided into four families: parallel, sequential, conversion and fully integrated. The decision of which family to adopt derives from the investigator's answer to two broad questions.

The first question concerns determining the sequence of steps that provides the optimal opportunity to answer the research questions. In *parallel designs*, quantitative and qualitative data are collected and analysed either simultaneously or with a time lag. Findings are then compared, resulting in more complete and meaningful conclusions. As an example, this design was utilised by Beck and Gable (2012) to explore secondary traumatic stress in labour and delivery nurses. Participants were asked to complete a quantitative secondary traumatic stress questionnaire as well as to describe their experiences of being present during a traumatic childbirth by means of an essay. Following analysis of the data, results were mixed during the interpretation, leading to a more robust analysis.

On the other hand, *sequential designs* involve two phases of data collection, with the second phase's research questions, sample, data and its analysis being rooted in the results of the first phase. For example, Cole (2009), who has explored the hand hygiene competence of student nurses, conducted an initial questionnaire study which collected quantitative data, the results of which then informed the design of an interview schedule used in a second qualitative phase, thus allowing the author the opportunity to explore, expand and confirm the findings of the first study. As a further example, Bailey and Hutter (2008), who studied HIV/Acquired Immune Deficiency Syndrome (AIDS) risk behaviour in Goa, India, first conducted interviews and focus groups in order to collect qualitative data. The themes that originated from this first phase were in turn used to design a questionnaire that collected quantitative data from a larger sample. The benefits of this design include the possibility of developing a quantitative tool which is relevant to the target sample, the ability to explore whether qualitative findings can be generalised to the wider study sample, as well as the possibility of drawing more meaningful conclusions by means of comparing quantitative and qualitative findings.

The second question highlighted by Tashakkori and Newman (2010) on which family to adopt entails the possibility of *converting* one type of data to another. This refers to modifying, for example, the qualitative themes identified following a thematic analysis to numerical indicators in order to allow them to be analysed statistically and integrated with one's quantitative findings. Alternatively, quantitative findings may be transformed into qualitative data. This design was used, for example, by Adolffson et al. (2011) who studied professionals' perceptions and applications of a classification of children's functioning and disability. Here, qualitative statements were gathered, from which themes emerged, and these were in turn classified into groups and analysed statistically. Tashakkori and Newman (2010) suggested that whilst researchers may choose to use one mixed method design family from parallel, sequential, or conversion, they may instead elect to use a combination

of these three families, known as the "*fully integrated mixed method design*".

Another popular typology is that of Creswell and Plano Clark (2011), who also differentiated between four categories of research design. *Convergent designs* (also known as parallel or concurrent) refer to a design where quantitative and qualitative data are collected concurrently. Equal priority is placed on either method and analysis is conducted independently, with results being mixed during overall interpretation. This design was utilised by Beck et al. (2009) in order to analyse the experiences and quality of life of older adult cancer survivors. Quantitative surveys and qualitative interviews were carried out simultaneously but independently and then repeated after two months. Findings from the two methodologies were then compared during the final interpretation stage in order to give a more complete picture.

Sequential design refers to a study split into two phases, with the second phase being designed to follow the first. The authors differ between two forms of sequential design, known as explanatory sequential design, where a quantitative study is followed by a qualitative study in order to explore and explain the earlier statistical findings, and exploratory sequential design, where qualitative data collection first takes the lead to explore a phenomenon, the findings of which are then used to design or choose quantitative instruments. In each of these sequential designs, the priority is usually placed on the first study. The explanatory sequential design has been employed, among others, in a study of children with mechanical respiratory support needs by Graham, Pemstein, and Palfrey (2008) which investigated the number of children needing respiratory support and gathered information on the challenges encountered in providing these individuals with multidisciplinary support (e.g. physical, speech and occupational therapy). The authors first acquired relevant quantitative data regarding the provision of services to such individuals from a census, analysed this and then presented their results to focus groups of key informants in order to elicit a discussion which explained and elaborated upon the earlier quantitative findings. Jones and Haynes (2006) also used a similar design to explore sexually transmitted diseases (STDs) in young people. A survey was first sent out to participants to explore the association between their knowledge of such diseases and their behaviour. This was then followed up by a number of focus groups in order to examine the young individuals' understanding of the negative outcomes of STDs in greater depth. On the other hand, a study by Beatty et al. (2004) made use of an exploratory sequential design to explore the use of rehabilitation outcome information in the acute inpatient rehabilitation 'industry'. The authors first conducted a series of telephone interviews with stakeholders and followed these up with a survey. Davila (2006) used an exploratory sequential design to develop, implement and evaluate an in-service programme about intimate partner violence. By means of a series of interviews, the researcher determined public health nurses' learning needs. A learning event was then developed and a quantitative survey of nurses' knowledge on the topic was administered prior to and following the event.

The embedded design (also known as nested design) involves collecting quantitative or qualitative data via a traditional design, but with a qualitative strand being added to a quantitative design (or vice versa). This is carried out with the aim of refining thinking or providing new insights. An example of this approach is provided by Victor, Ross, and Axford (2004) who analysed the impact of a care-based health promotion intervention for individuals with knee osteoarthritis. A randomised controlled trial was set up, which included an initial structured interview and a number of quantitative outcome measures for pain, quality of life, mental health, coping with arthritis and osteoarthritis knowledge. A qualitative strand was also incorporated in order to explore participants' experience of living with the disease and individual goals, amongst other factors. This was accomplished by means of a structured baseline interview with open-ended questions, patient diaries kept for the duration of the intervention where participants reviewed their symptoms, detailed medication use and identified their goals, and finally by an analysis of themes that emerged from discussions of patients' experiences during group teaching sessions.

Multiphase designs refer to multiple projects with a common purpose that are conducted over time and generally involve sequential and convergent elements. A three-year study of the integration of nurse practitioners into clinical practice in British Columbia (Sangster-Gormley et al., 2015) provides an example of this research design. An initial quantitative survey of patient patterns was followed by qualitative focus groups with relevant stakeholders in the first year of the project. In the second year, four research studies were carried out concurrently: patient surveys and co-worker surveys with both quantitative and qualitative elements, qualitative focus groups and qualitative interviews with nurse practitioners. The findings of these stages led to qualitative case studies and patient interviews in the third year of the study, as well as a quantitative survey of patient patterns. The sequential nature of this project, where the design of most of the qualitative elements emerged from the preceding stages, ensured that information collected was relevant and at the same time allowed researchers to explore data from the earlier stage in further detail.

While both typologies include many similar components, it is worth noting that each has developed considerably over the years and this, coupled with the number of other typologies, has led some authors to express discomfort at the lack of consensus and the models' over-refinement (Bryman, 2006). In fact, Bazeley (2009) suggested that in order for mixed methods research to mature, it should focus less on design typologies and more on analytic techniques that support integration. Additionally, Bryman (2006) noted that early commitment to a particular research design is not always possible or good practice as research outcomes in mixed methods are not always predictable. Referring to the proliferation of designs, Teddlie and Tashakkori (2010) suggested that it indicated healthy development within the mixed methods community and expressed confidence that common components of different typologies would be identified and reconciled in the future.

In their analysis of 168 mixed method studies in healthcare research, Östlund et al. (2011) reported that the parallel data analysis approach was most widely used (58%), followed by sequential data analysis (27%) where qualitative studies generally informed the design of clinical tools and research measures for the second phase of the study, or followed quantitative studies to explore their findings in greater depth. In both parallel and sequential data analysis studies, authors rarely addressed the weighting and priority given to each method and thus the impact of the different methods on the studies' findings could rarely be gauged. Östlund et al. (2011) also noted that results of such studies could be classified as *convergent*, where qualitative and quantitative findings lead to the same conclusion, *complementary*, where the two sets of results would supplement each other, or *divergent*, where quantitative and qualitative results provided different, possibly contradictory, results.

6 Conclusion

Despite its limitations, mixed methods research is widely regarded as contributing significantly to health science research (Östlund et al., 2011). By combining quantitative and qualitative data in the same study, researchers are able to benefit from the strengths of each approach while minimising their shortcomings. In practice, this endeavour facilitates health science researchers' investigations into the complex and multifactorial nature of human health and illness.

Researchers who employ a mixed method approach for the first time can easily feel overwhelmed by uncertainty regarding the method's philosophical underpinnings as well as the plethora of mixed methods research typologies. While further research and debate is warranted, health science researchers seeking solutions for real-world problems are increasingly accepting pragmatism as the paradigm of choice.

While a common typology that has the potential to introduce a universal language to mixed methods research remains elusive, the most popular classifications do have common elements. The favoured typology will depend on the research questions, but in most cases researchers choose between either collecting quantitative and qualitative data simultaneously, often termed a parallel design, or collecting data in phases - a sequential design. Whilst the results of parallel designs are pooled at the end of data collection, providing a final rich dataset, the sequential design allows the results of the early phases to guide the development of procedures and instruments for later phases. When, for example, phase one involves qualitative data, phase two generally involves the development of a research tool to identify if qualitative findings can be generalised to the wider study population. Alternatively, when phase one involves quantitative data, the second phase often revolves around explaining initial findings. Whichever method is chosen, mixed methods provide researchers with the opportunity to develop richer and more meaningful data through their integration of qualitative and quantitative findings.

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8 Conflicts of interest

The authors report no conflicts of interest.

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Research paper

FAECAL IMMUNOCHEMICAL SCREENING TESTS FOR COLORECTAL CANCER: A SINGLE-CENTRE STUDY FROM THE CZECH REPUBLIC

Jan Pospichal, Vit Blanar

Faculty of Health Studies, University of Pardubice, Czech Republic

Abstract. The goal of this study is to describe the temporary state of faecal occult blood screening in the Czech Republic. Qualitative and quantitative methods of faecal immunochemical testing for haemoglobin were compared and evaluated retrospectively for a period of four years. Screening was actively offered to asymptomatic individuals within their preventive check-ups, starting at the age of 50. Two types of faecal immunochemical tests were used for screening: a qualitative and a quantitative method. Any positive tests detected during screening were followed up by a total colonoscopy. The research sample contained 454 persons; 191 individuals (42.07%) were tested using the qualitative method and 263 individuals (57.83%) were tested through the quantitative method. The qualitative test's specificity for our sample was 75.84%. Better results were yielded by the quantitative test, where the specificity of the sample reached 94.69%. The latter represented an improvement in faecal occult blood test (FOBT) screening in the Czech Republic that can result in more frequent detection of the disease and a lower mortality rate. Occult blood test screening is ideal for the successful prevention of colorectal cancer (CRC) developing from polyps.

Keywords: Colorectal cancer (CRC), faecal immunochemical tests for haemoglobin (FIT), faecal occult blood test (FOBT), prevention, screening

1 Introduction

The term colorectal cancer (CRC) describes the condition of the malignant transformation of the columnar epithelium of the large intestine and the rectum. In the Czech Republic, statistics for this condition are recorded under the International Classification of Diseases (ICD-10) codes

C18, C19, C20, and C21, i.e. malignant neoplasms of the colon, recto-sigmoid junction, rectum, and anus (Institute of Health Information and Statistics of the Czech Republic, 2013). Incidence of CRC within the Czech Republic is still the highest in Central Europe. According to the Institute of Health Information and Statistics of the Czech Republic (2013), the incidence of the disease in the Czech Republic in 2012 was of 36.79 ASR-W (age-standardised rate - world) and mortality was of 16.38 ASR-W. Due to certain common dietary habits, a high mortality and increasing incidence of the disease were observed predominantly in Slovakia, the Czech Republic and Hungary.

The incidence of CRC in the Czech Republic has been rising since 1960. In the past 20 years, the Czech Republic and Hungary have been the leading countries in the list of CRC incidence (Fric et al., 1994). Unfortunately, CRC is often diagnosed at late stages with poor prognosis and negative social impact for the patients. Thus, the need for improved secondary prevention of CRC has been a main focus in the Czech Republic, including the implementation of faecal occult blood screening at two-year intervals for individuals aged 50 years and over. The secondary prevention plan has been divided into two steps:

- (1) regular population screening whereby diagnostic testing is carried out by general practitioners and gynaecologists in asymptomatic individuals;
- (2) follow-up surveillance including long-term observation of high-risk individuals.

Indeed, follow-up surveillance programmes are specified according to the individual's risk for CRC development (Zavoral et al., 2014).

Based on previous experience, the Ministry of Health of the Czech Republic (2009) started addressing the innovation and standardisation of the screening programme. At annual intervals, people aged between 50 and 54 years attended faecal occult blood test (FOBT) screening at the general practitioner's or gynaecologist's clinic. After reaching the age of 55, the intervals become biennial. The screening is free of charge for the target population. A primary screening colonoscopy could also be used as a screening method at the age of 55; this is performed in selected centres, and can

Correspondence to Jan Pospichal
 (jan.pospichal@upce.cz)

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be repeated after 10 years in the case of a negative finding. However, colonoscopy centres may become overloaded with the demands of this procedure. Entire screening output data are evaluated by the National Reference Centre (Dušek, 2015).

Previously, the guaiac FOBT was used as a screening test for CRC. The guaiac FOBT has low efficacy, requires restriction in diet and must be repeated to confirm the result. For this reason, the faecal immunochemical test for haemoglobin (FIT) was used as it has higher sensitivity, but nonetheless also has a higher false positivity rate. Since 2009, FIT has been preferred over the guaiac FOBT (Zavoral et al., 2014). The qualitative FIT method uses one cut-off level as given by the manufacturer of the device and results are issued as positive or negative. The quantitative FIT provides results for the presence of haemoglobin in stools as $\mu\text{g Hb/g faeces}$. Nowadays, many medical centres use the quantitative FIT method, which reportedly detects around 81.8% of CRC (47.8% - 96.8%), is able to reduce false positive findings, and has a specificity of 96.9% (96.4% - 97.4%) (Allison et al., 2014).

Nowadays, the Czech Republic does not have the highest rate of CRC incidence. Currently, Hungary holds the first position; the Czech Republic has the second highest incidence in men and the third in women. The second highest CRC incidence in women is held by Slovakia (Institute of Health Information and Statistics of the Czech Republic, 2010).

1.1 The nurse's role

The nurse has an essential role in the implementation of a CRC screening programme, most importantly in providing the necessary information to the patients in order to increase their knowledge of and participation in the screening programme. This will immensely improve primary, secondary, tertiary and quaternary prevention (Joseph, Vaughan & Stand, 2015). In addition, the nurse also has to be knowledgeable about the actual testing, as well as storage and transportation of the sample. It is the nurse who records the measurements and informs the doctor of the results, who subsequently determines the follow-up procedure. In some countries, the nurse also performs the screening colonoscopy (Joseph et al., 2015). This may be a solution for overloaded colonoscopy workplaces. However, an even better solution would be to optimise the screening methods, including decreasing false negative and false positive results (Tursi, 2013). In the Czech Republic, colonoscopy examinations are performed only by a medical doctor.

In January 2014, a direct invitation system, applicable also for FIT, was introduced. The system works on the principle of sending letters to individuals from the target population group. This is performed through health insurance companies or general practitioners. Direct invitation aims to reach a larger population through screening methods so as to prevent the late detection of tumours (Zavoral et al., 2014; Suchanek et al., 2014).

1.2 Research aims

The research aims of the present study were the following:

- (1) to compare qualitative and quantitative FIT screening methods
- (2) to establish which of the above methods produces the lower number of false positive results
- (3) to compare colonoscopy results of patients with a positive FIT screen to the incidence rate of the Czech Republic.

2 Methods

A retrospective monocentric quantitative research method was employed. All the data originated from the office of a single general practitioner in a town of over 14,000 inhabitants where all the tests were performed between the 1st of January 2010 and the 1st of December 2014. All data was measured by a single nurse, with training provided by the manufacturer of the tests. Prior to the examination, the nurse provided instructions to patients on how to complete the FIT, collect the samples and transport them to the general practitioner's office.

2.1 Research sample and testing

The research sample contained 454 asymptomatic individuals (Table 1) who were examined using the qualitative or quantitative immunochemical FOBT during their check-ups. Participants were aged 50 years or older and none of them had undergone a colonoscopy or had been examined for the presence of blood in their stools within the last ten years. Furthermore, none of the research subjects reported a history of bowel problems, including chronic inflammation of the large intestines, or required surgical intervention to treat any intestinal problems.

A first group of 191 (42.07%) samples was analysed using the qualitative FIT method, whereas a second group of 263 (57.83%) samples was analysed using the quantitative FIT method. The threshold value for a positive FIT finding was set at $75 \mu\text{g/l}$. According to Faecal Immunochemical Tests for Haemoglobin Evaluation Reporting (FITTER) standards (Fraser et al., 2015), the formula for the conversion of haemoglobin quantity from $\mu\text{g/l}$ (ng/ml) to $\mu\text{g/g faeces}$ is as follows: $\mu\text{g haemoglobin/g faeces} = (\text{ng haemoglobin/mL}) \times (\text{volume of buffer in the device in mL}) / (\text{mass of faeces collected in mg})$. Our cut-off was $75 \mu\text{g/l}$, which is equal to $13 \mu\text{g Hb/g}$, allowing for the comparison of results from the pre-cancerous screening.

All examined individuals with a positive FIT were offered a follow-up colonoscopy with a prospective polypectomy. However, some participants (14 individuals) refused a follow-up procedure.

For research purposes, all data was anonymised. Research was conducted in accordance with the recommendations of the Helsinki Declaration and was approved by the Ethics Committee of the medical centre where the research took place.

2.2 Follow-up of the screening test results

Positive results of the qualitative and quantitative FIT were compared with the colonoscopy results as well as with the histology results from biopsies taken during colonoscopy. The latter acted as the gold standard for the diagnosis of pre-colon cancer and CRC. Colonoscopy and histological results were divided into five categories: non-adenomatous polyps, adenomatous polyps, carcinoma, without abnormalities, and other findings (including haemorrhoids, diverticula or inflammatory changes).

Table 1. Demographic characteristics of the 454 participants

Characteristics	Valid N	Value
Females	275	60.57%
Males	179	39.43%
Age (years)		
Mean \pm SD		61.86 \pm 8.62
Range		50 – 86
Qualitative FIT	191	42.07%
Quantitative FIT	263	57.93%

FIT: faecal immunochemical tests for haemoglobin
SD: standard deviation

2.3 Statistical analysis

For statistical data processing, MS Excel 2010 and Statistica 12 software provided by DELL were used. Categorical variables were compared using the Fisher exact test with Freeman-Halton extension for 2x3 contingency tables, due to small sample sizes in some of the categories. A confidence interval of 95% was used. Specificity was calculated as the number of negative subjects divided by the number of negative subjects and the number of false positives.

3 Results

3.1 Participation in the screening programme

Between the 1st of January 2010 and the 1st of December 2014, 179 men (39.43%) and 275 women (60.67%) were examined for faecal occult blood (see Table 1). By the end of data collection, the medical centre where the research took place registered a total of 1,553 individuals aged 50 years and over. Out of the total, 25.64% men and 32.21% women attended the CRC screening. In total, 29.23% of the entire number of individuals was examined, which is higher than the regional average by 4.2%. A flow diagram of the study is seen in Figure 1.

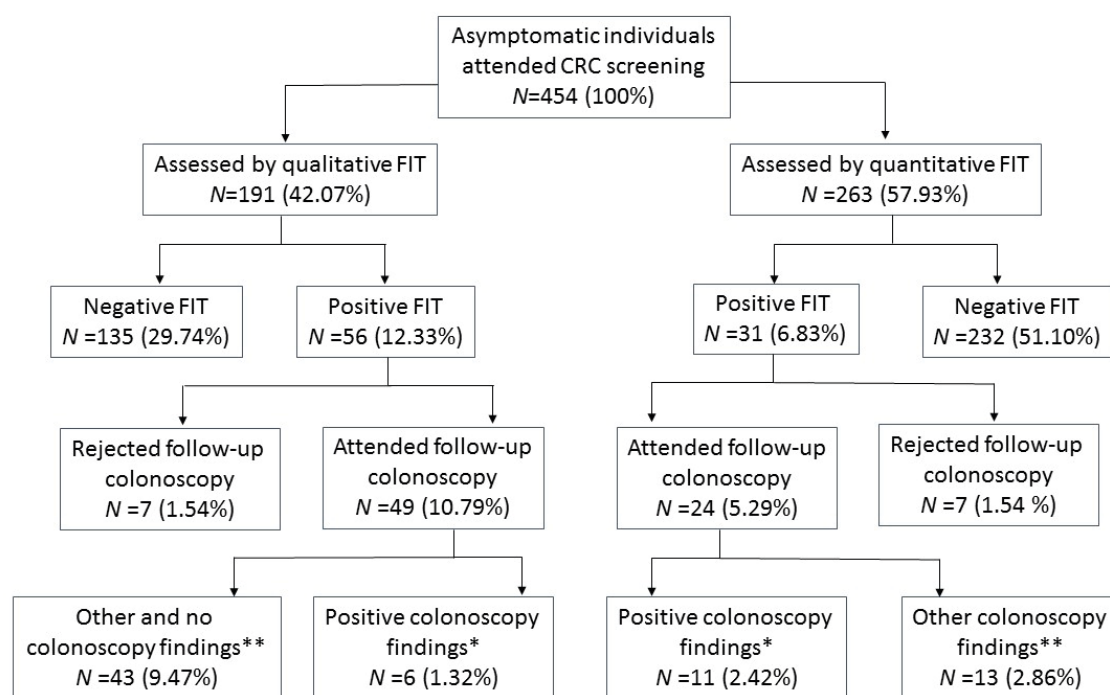


Figure 1. Flow diagram of the study

*'Positive findings' include polyps and carcinoma.

**'Other findings' include inflammation, diverticula and haemorrhoids.

3.2 Immunochemical screening test results

Out of 454 patients examined by the qualitative or quantitative immunochemical method, 87 (19.16%) findings were positive (Table 2), whereby 56 positive findings were detected by the qualitative FIT method and 31 positive findings by the quantitative FIT method. A total of 14 patients refused to attend a colonoscopy, and were thus missing in further statistical analysis. There was a decrease in the false positive results for the categories ‘Other findings’ and ‘No abnormalities’ when comparing results of the quantitative method with the qualitative method, implying that more of the positive results were due to the presence of polyps and malignant transformations. The calculated specificity when using the qualitative FIT method was of 75.84%, and it reached 94.69% when using the quantitative one; the false positive rate for the qualitative FIT was of 24.16% whereas that for the quantitative FIT was of 5.31%.

Table 2. Colonoscopy findings for the positive results of the qualitative and quantitative FIT

Colonoscopy finding	Qualitative FIT value; N = 49 N (%)	Quantative FIT value; N = 24 N (%)
Non-adenomatous polyps	4 (8.16)	2 (8.33)
Adenomatous polyps	2 (4.08)	6 (25.00)
Carcinoma	0	3 (12.50)
Other findings*	35 (71.42)	13 (54.16)
No abnormalities	8 (16.32)	0

FIT: faecal immunochemical tests for haemoglobin
 **‘Other findings’ include inflammation, diverticula and haemorrhoids.

Colonoscopy findings were grouped into three categories (‘positive findings’, ‘other findings’ and ‘no abnormalities’) for statistical evaluation using a Fisher’s exact test (Table 3). A statistically significant difference was found between the different types of positive results detected by the qualitative and quantitative FIT method in relation to the results of colonoscopy examinations. The Fisher’s exact test *p*-value was equal to 0.0027.

Table 3. The Fisher’s exact test for colonoscopy findings in qualitative and quantitative FIT

Colonoscopy finding	Qualitative FIT value N (%)	Quantitative FIT value N (%)	<i>p</i> -value
Positive findings*	6 (12%)	11 (46%)	0.0027
Other findings** & No abnormalities	43 (88%)	13 (54%)	
Fisher’s exact test			0.0027

FIT - faecal immunochemical tests for haemoglobin
 *‘Positive findings’ include polyps and carcinoma.
 **‘Other findings’ include inflammation, diverticula and haemorrhoids.

An overview of the measured values is depicted in the boxplot in Figure 2, where the small inner box represents the median statistic, accompanied by the lower and upper quartiles (25th and 75th percentiles), and the whiskers show the ranges. Using the quantitative FIT, haemoglobin in stools values ranged from 14.28 µg Hb/g faeces to more than 170.00 µg Hb/g faeces. The median was 52.19 µg Hb/g faeces and the standard deviation was 56.78 µg Hb/g faeces. The measured numerical value enabled one to estimate the severity of the findings and to optimise further diagnostics.

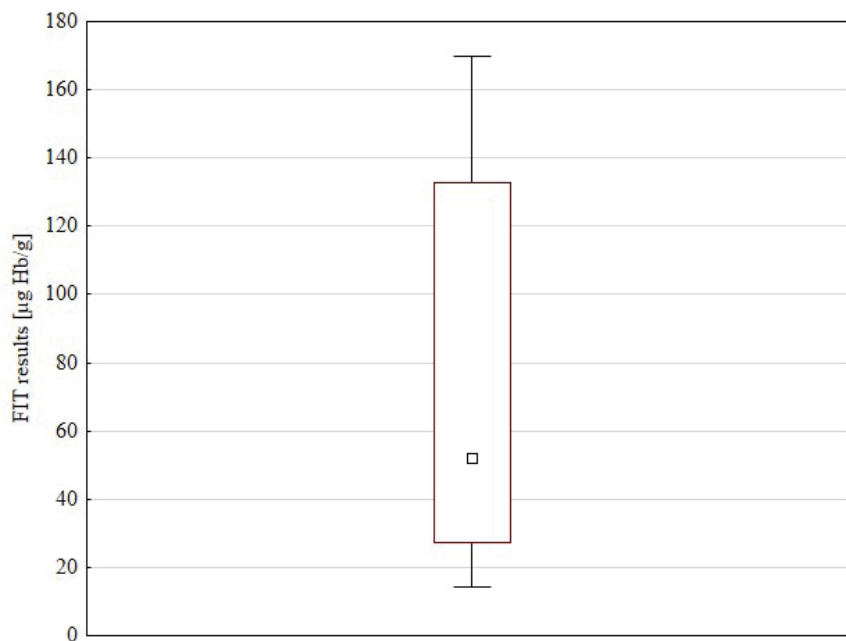


Figure 2. Boxplot representing the values obtained by quantitative FIT [µg Hb/g]

When comparing the results of both methods according to age and gender, the highest incidence in men was found at the age of 71 and older, amounting to 29.41% of the examined individuals. The second highest incidence was in the age category 50 – 60 years (19.19%). In women, the highest incidence was detected in the age group 50 – 60 years, with 20.00% examined patients. The second highest incidence was in the age category of 71 years and higher, with 12.24%.

4 Discussion

The results of this study imply that using the quantitative method of occult blood testing significantly reduces false positive findings and thus, fewer patients are referred for a colonoscopy. This reduces costs and, in turn, more effort is directed towards the detection of CRC and pre-cancerous conditions. Chauvin, Josselin and Heresbach (2013) report the same findings and add that the waiting time for a diagnostic procedure is significantly reduced due to fewer false positive findings. Chauvin et al.'s (2013) study was aimed at comparing guaiac FOBT and FIT. Furthermore, the replacement of the qualitative FIT by the quantitative FIT has caused a decrease in findings in the category 'Other findings' from 71.42% to 54.16%, meaning that there was an improvement in the test specificity of our research sample to 94.69%. The quantitative FIT specificity detected in this study was 1% lower than that reported by Dušek et al. (2014). Similarly, the high positivity rate detected by the qualitative FIT over the quantitative FIT in the study by Park et al. (2012) is comparable to that reported in this study. In 2013, Ou et al. confirmed that the quantitative FIT was able to accurately detect the presence of advanced colorectal neoplasms and that the quantitative FIT offered a much higher sensitivity in detection of CRC when compared to the qualitative FIT. According to Chen et al. (2012), testing of transferrin levels in faeces could aid and improve the screening programme of faecal occult blood by quantitative FIT in the high-risk population. Another advantage of the quantitative FIT is the possibility to prioritise patients based on the level of $\mu\text{g Hb/g}$ faeces detected, thus accelerating the diagnostic process, facilitating earlier treatment options and improving survival outcomes of individuals with higher levels (Rozen et al., 2009). Comparison of the ASR-W incidence statistics for ICD-10 diagnoses C19 – C21 in 2010 in the Czech Republic with European and global averages leads to the conclusion that Czech figures are above average. In the Czech Republic, the incidence in the general population (men and women) was 39.2, while the European average was 31.7. In the United States, the average is even lower at 29.2. Recently, however, the Czech Republic has been very successful in decreasing mortality related to these conditions; this is where early detection is essential. In 2004, in the Czech Republic, C19 – C21 ASR-W mortality was 24.7 for the general population (men and women). In 2010, the values dropped to 17.8 for the general population (Institute of Health Information and Statistics of the Czech Republic, 2010). Thus, there is clear proof that implementation of regular periodic screening can act as an effective tool for the early diagnosis and treatment of CRC.

The future goal is to screen a higher percentage of the population aged 50 years and over, in order to increase the efficiency and benefit of the screening programme. This can be achieved by direct invitation of registered persons attending clinics and hospitals, increasing the awareness of CRC within the population and motivating individuals to participate in the screening programme. In our research sample, the overall screened population percentage was 29.2%, regardless of gender, which is 4.5% higher than the regional average (Institute of Health Information and Statistics of the Czech Republic, 2010). There is a limitation in our research because of the different sample size tested in the two screening methods and, unfortunately, both FIT methods were not performed on every sample.

5 Conclusion

Apparently, FOBT is the focus of CRC diagnostics in the Czech Republic. It is the improvement in screening methods and management which enables detection of pre-cancerous conditions or cancer in the early stages of the disease.

The most important results of our study are that firstly, from the positive results detected by the quantitative FIT method, none of the samples fell in the 'No abnormalities' category when confirmed by the follow-up colonoscopy, contrasting with the outcomes of the qualitative FIT method; secondly, a lower percentage of the positive results detected by the quantitative FIT (51.46%) as opposed to the qualitative FIT (71.42%) method were due to benign conditions such as inflammation, diverticula and haemorrhoids; lastly, specificity when using the quantitative FIT was higher than the qualitative FIT method. The essential role in this preventive-diagnostic-treatment process is held by the nurse. The nurse educates the patients before and during examination, performs the test, reads the measurements, and informs the doctor of the result, who subsequently determines the follow-up procedure. Another contribution of nurses could be within primary CRC prevention, by providing nutrition tips and advice. Finally, increasing the number of examined individuals might increase the five-year relative survival rate, which is one of the main goals of our preventive programme.

6 Funding

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7 Conflicts of Interest

The authors report no conflicts of interest.

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Research paper

AUDITORY AND LANGUAGE PROCESSING SKILLS IN MALTESE CHILDREN: A COMPARATIVE STUDY

Nadine Tabone¹, Melissa Vassallo¹, Charlene Magri¹, Helen Grech¹, Daniela Gatt¹, Doris-Eva Bamiou²

¹Department of Communication Therapy, Faculty of Health Sciences, University of Malta, Msida, Malta

²UCL Ear Institute, University College London, London, UK

Abstract. Auditory processing disorder is described as a mixture of unrefined listening skills which, despite normal hearing, causes poor speech perception. These difficulties have also been reported in children with a diagnosis of language impairment (LI), literacy difficulties (LD)¹, and attention-deficit/hyperactivity disorder (ADHD). The purpose of this study is to describe and compare the listening performance of typically developing (TD) children with those diagnosed with LI, LD, and ADHD on an assessment battery of auditory processing (AP) and language processing (LP). One hundred and one TD children and 53 children with a clinical diagnosis were assessed using four subtests of AP presenting linguistic stimuli, three AP subtests with non-linguistic stimuli and an assessment of LP. Parents of all children were required to fill in a questionnaire related to their listening difficulties. Parental report for the TD group on average yielded the lowest score, indicating fewer difficulties with listening skills in the TD group. The listening difficulties exhibited in the Maltese participants diagnosed with LI, LD and ADHD were mainly specific to the AP subtests using linguistic stimuli. The LI and LD groups generally performed significantly worse than the TD group on all AP subtests using linguistic stimuli, while the ADHD group performed significantly worse than the TD group on some of these tests. The same pattern did not emerge for the subtests using non-linguistic stimuli. Few significant effects between groups were evident. The LI groups were found to perform the weakest in all tests of language processing.

Keywords: auditory processing, language processing, children, language impairment, literacy difficulties, attention-deficit/hyperactivity disorder

Correspondence to Nadine Tabone
 (nadine.tabone@um.edu.mt)

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¹ Throughout this text, the term 'literacy difficulties' will be used to refer to any impairment or difficulty with reading and spelling.

1 Introduction

Auditory processing (AP) is the ability to listen, understand and respond to information heard through the auditory channels. It involves both the detection of sound and its transmission through the auditory pathways to the brain (Yalcinkaya, Muluk & Sahin, 2009). The information processing theory states that both bottom-up (sensory encoding) and top-down factors (cognition, language, and higher-order functions) work together and exert a strong influence on information processing (Mülder, Rogiers & Hoen, 2007). Auditory processing disorder (APD) is complex and heterogeneous in nature, resulting in a lack of consensus in terms of definition, assessment and diagnostic criteria (Kamhi, 2011; Wilson & Arnott, 2013). It has been described as a mixture of unrefined listening skills causing poor speech perception. This is especially the case in noisy environments, which pose a heavier challenge to the individual (Rosen, Cohen & Vanniasegaram, 2010). These difficulties are evident despite the presence of normal hearing (de Wit et al., 2016).

Although there is agreement regarding the manifested symptoms, there are conflicting reports concerning the cause of APD. Children presenting with this condition are reported to find difficulty understanding verbal instructions and tend to exhibit poor attention (British Society of Audiology, 2011; Moore, 2011). Listening skills are key to the enhancement of language and learning skills (Jourkouye & Vahdani, 2013). Moore et al. (2010) investigated the correlation between tests of AP and attention and cognition. Their results indicated that attention and cognitive scores are valid predictors of communication, suggesting that the primary cause of APD is a difficulty in attention skills. In fact, children with attention-deficit/hyperactivity disorder (ADHD) have been documented to demonstrate listening difficulties (e.g. Lucker, Geffner & Koch, 1996; Keith & Engineer, 1991; Ludlow et al., 1983; Sutcliff et al., 2006; Huang et al., 2012). A high comorbidity between APD, language impairment (LI) and reading disorder has emerged in studies (e.g. Sharma, Purdy & Kelly, 2009). Similarly, parental report of communication, listening skills and general behaviour in children who had previously been diagnosed with either specific language

impairment (SLI)² or APD have resulted in a very similar performance (Ferguson et al., 2011).

Some studies have investigated the link between bilingualism and auditory processing (e.g. Krizman et al., 2014; Golestani et al., 2007; Wong et al., 2008). Of interest, Krizman et al. (2014) collected data from auditory evoked responses together with data from attentional control and language skills in monolingual and bilingual speakers. The bilingual speakers revealed better attentional control and increased consistency in brainstem and cortical responses to speech sounds. Many Maltese individuals are considered to be early sequential bilingual speakers to whom the second language is introduced soon after the acquisition of the first language (Grech & McLeod, 2011). To date, there has been no published data on auditory processing in the Maltese paediatric population. In light of this, and considering the local bilingual situation, it is relevant to examine the auditory processing skills in this population, and compare the performance of typically developing (TD) children with that of children diagnosed with LI, literacy difficulties (LD) and ADHD. This study investigated the following issues:

- (1) How do the perceived listening difficulties of children diagnosed with LI, LD, and ADHD compare with TD children?
- (2) Is there a significant difference between the performance of TD children and those with a diagnosed LI, LD, and ADHD on an assessment battery of auditory and language processing?
- (3) Is there a significant difference in the performance of each clinical group on the assessment battery?

2 Method

2.1 Participants

The total sample consisted of 154 children, aged between 7;00 and 9;11 years. The children were allocated to four different groups: TD, LI, LD and ADHD. The TD group ($N = 101$) was recruited by means of random sampling via the National Statistics Office of Malta, which supplied a random list of addresses of families with children in the age range needed. The selection criteria are shown in Table 1. The children forming the LI group ($N = 11$) were identified and recruited through the Speech Language Department within the Ministry of Health, Malta. A set of criteria (Table 1) was devised to recruit children based on specific characteristics rather than on the diagnosis of SLI or LI given by the respective speech-language pathologist (SLP). This approach to recruitment was motivated by the fact that locally, SLPs tend to differ in the test batteries and diagnostic criteria used to identify SLI. Recruiting children

on the basis of these criteria allowed for more uniformity in the LI participant group. The selection criteria were based on Leonard (2014), with additional consideration of the bilingual context specific to the bilingual situation in Malta.

Table 1. Selection criteria for the TD participants and those with LI

TD	LI
Maltese citizen	Maltese citizen
Aged between 7;0 and 9;11 years	Aged between 7;0 to 9;11 years
Bilingual: Maltese/English	Bilingual: Maltese/English
No history of hearing impairment/chronic ear infections	No history of hearing difficulties/chronic ear infections
No speech and language impairment	Currently receiving speech-language therapy services due to presenting language difficulties
No cognitive impairment	Non-verbal IQ of 85 or better if provided with a report
No attention difficulties	No attention difficulties
No neurological pathology	No evidence of seizure disorder, cerebral palsy and/or brain lesions
No behaviour problems	No symptoms of impaired interactions as in autism spectrum disorder
No long-term medication	Normal oral structure and oral motor function but might or might not have co-morbid persisting articulatory/phonological difficulties

The children included in the LD group ($N = 12$) were recruited following interest from the parents on receiving the participation letter targeting the TD sample. These children had all been diagnosed with literacy difficulties by an educational psychologist. The criteria used for including these children were similar to the LI group, with the difference that they did not exhibit any oral language impairment.

The final group recruited for this study comprised the children diagnosed with ADHD ($N = 30$). They were recruited through the national Child Guidance Clinic. All participating children were diagnosed with ADHD by a psychologist. They were to have no current intake of medication, not be attending any speech-language therapy services and present with no additional cognitive and language disorders.

The research study obtained approval from the University Research Ethics Committee (UREC) at the University of Malta. Permission to access to potential participants was obtained from the National Statistics Office, the Speech-Language Department and the Child Guidance Clinic. Signed parental consent and verbal child assent were acquired from all participants.

² Traditionally described as a deficit in language structure (Davies, Andrés-Roqueta & Norbory, 2016).

2.2 Test procedures

2.2.1 Peripheral hearing

Each child underwent an initial hearing screening, including an otoscopic examination, immittance audiometry and pure-tone audiometry. All participants exhibited no abnormalities on otoscopic examination and also showed normal hearing levels and immittance measures.

2.2.2 Questionnaire

Participants' parents completed a questionnaire available in both English and Maltese (Questionnaire of (Central) Auditory Processing; QCAP) (Appendix 1: English version), developed and validated as part of another study (Tabone, in progress), and requesting information about listening difficulties commonly found in children suspected of presenting with APD. This questionnaire consists of five questions requesting background information related to a history of otological problems and other developmental disorders. This is followed by 20 items relating to listening behaviour in different listening environments. The children are rated on a 5-point Likert scale, where a score of 5 indicates substantial difficulty, while a score of 1 indicates no difficulty.

2.2.3 Assessment battery of auditory processing

Auditory processing skills were assessed using five behavioural tests. All tests were presented through TDH-39 earphones connected to a clinical audiometer at 50 dB HL. Binaural integration and separation were examined through two subtests of the Dichotic Digit Test (DDT) (Musiek, 1983), specifically during the 'free recall' (FR) and 'simple focused attention' (SFA) tasks. The participants were presented with four numbers, two presented to each ear simultaneously. In the FR task they were requested to repeat all four numbers, while the SFA task required them to focus on one ear and repeat only what was heard in that ear, ignoring the other ear. Throughout these tests, both ears were tested simultaneously. Temporal processing was assessed through the Duration Patterns Test (DPT) (Musiek, Baran, & Pinheiro, 1990), Frequency Patterns Test (FPT) (Musiek, 1994) and the Gaps-in-Noise Test (GIN) (Musiek, 2003). The Patterns Tests included sequences of three consecutive tones, differing in either duration or frequency. A total of 30 items were administered (15 in each ear) and the participants were to identify the patterns (long versus short or high versus low). The GIN test required the children to identify gaps ranging between 2 and 20 ms embedded in bouts of white noise. Auditory closure was assessed through two subsets of language specific (Maltese- and English-based) non-word repetition tests (NWRT) in the presence of background speech babble (NWRT(n)) at approximately a +5 signal-to-noise ratio (SNR) (Calleja, Grech, & Bamiou, 2012).

Each subtest consisted of a total of 24 non-words of varied syllable length and complexity, which the participants were to repeat. The non-words were spoken by a female native Maltese speaker. These tests presented stimuli to the right and left ears separately, randomising the ear with which the test first starts. The DDT, DPT, FTP and GIN were scored in terms of percentage correct responses. The responses from the two NWRT(n) were phonetically transcribed and scored for the total percentage words with errors.

2.2.4 Tests of language processing

A language specific NWR task, similar to the NWRT(n) but with no background noise (NWRT(qu)), was used to assess phonological working memory. The participants were to repeat the non-words presented. As in the NWRT(n), each list (Maltese- and English-based) included 24 items. The performance was scored in the same way as the NWRT(n). The Sentence Imitation Task (SIT), part of the Language Assessment for Maltese Children (LAMC) (Grech, Franklin & Dodd, 2011), was included to assess the children's working memory and language processing skills through comprehension followed by the reconstruction of sentences. They were required to repeat 10 sentences (presented in their primary language) of increasing length. A score of 2 was given if the complete sentence was repeated clearly and correctly, a score of 1 was given when 50% or more of the sentence was repeated and a score of 0 was given if less than 50% of the sentence was repeated.

2.3 Procedure

The TD participants completed the entire test battery in two sessions lasting approximately one hour each. The children forming the clinical groups required a third session due to the inability to complete all subtests within the two sessions. This was expected given their diagnoses. These children required more breaks and repeated explanation of the tasks. During each session, frequent short breaks were provided. All testing was carried out in a sound treated room. The administration sequence of the auditory and language processing tests was varied within the sessions.

2.4 Statistical analysis

All measures were tested for normality using the Shapiro-Wilk test due to the relatively small sample sizes. The results indicated that the data for the TD group were not normally distributed. The distribution of data for the clinical groups varied. The data obtained from the ADHD group were not normally distributed, with the exclusion of the four NWRT subtests. The other two clinical groups brought out data of generally normal distribution. In light of the variation in distribution, the data were analysed using non-parametric means. Significance was established to be ≤ 0.05 .

3 Results

3.1 Questionnaire

The QCAP correlated moderately with the Children’s Auditory Processing Performance Scale (CHAPPS) (Smoski, Brunt, & Tannahill, 1998) ($p = 0.05$) and demonstrated strong internal and test-retest reliability (>0.90 ; $p = 0.01$). Parental report on various aspects of listening skills was obtained through the QCAP, the means of which are plotted in Figure 1. Responses to the questions were analysed to provide a total score of the perceived (subjective) difficulty and also in terms of specific skills emerging in an exploratory factor analysis (Tabone, Grech & Bamio, 2016a), namely auditory attention and memory, conversation skills, sensory stimulation, listening in noise, and social situations. Figure 1 demonstrates that the parental report scores for the TD

group were on average lower than those for all the clinical groups, indicating fewer difficulties in the former with listening skills.

The Kruskal-Wallis test demonstrated statistically significant differences ($p < 0.01$) between groups in both the total questionnaire score and each of the subscale scores (Table 2). Through the Mann-Whitney test, significant differences were evident between the TD group and each of the clinical groups, with the latter obtaining poorer scores. No significant differences between clinical groups emerged, suggesting that similar listening difficulties were reported by parents of children in the clinical groups.

The total QCAP score was correlated with each of the AP subtests in the assessment battery. Significant correlations were found between the QCAP and all subtests using linguistic stimuli. The stronger correlations were with the DD tests: DD(FR) on the right ($r = -0.42$, $p < 0.001$) and left ($r = -0.45$, $p < 0.001$) and the DD(SFA) in both ears (right:

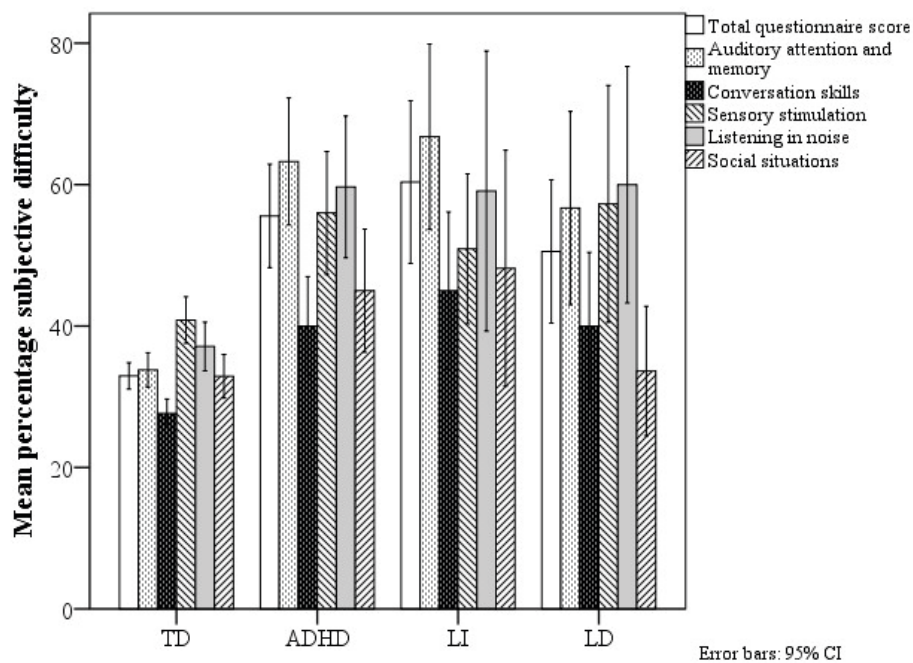


Figure 1. Mean scores of listening skills as reported by parents in the QCAP

Table 2. Comparison of means in the QCAP

QCAP	Kruskal-Wallis			Mann-Whitney					
	χ^2	df	p	TD vs ADHD	TD vs LI	TD vs LD	ADHD vs LI	ADHD vs LD	LI vs LD
				p	p	p	p	p	p
Total score	53.6	3	<0.001	<0.001	<0.001	<0.001	0.669	0.233	0.138
Auditory attention and memory	53.3	3	<0.001	<0.001	<0.001	<0.001	0.757	0.239	0.122
Conversation skills	29.5	3	<0.001	<0.001	0.001	0.001	0.421	0.789	0.390
Sensory stimulation	17.8	3	<0.001	0.001	0.042	0.023	0.653	0.976	0.665
Listening in noise	30.1	3	<0.001	<0.001	0.004	0.003	0.917	0.929	0.868
Social situations	16.4	3	0.001	0.001	0.007	0.447	0.753	0.171	0.149

Table 3. Comparison of means in the auditory processing subtests using linguistic stimuli

Subtests using linguistic stimuli	Kruskal-Wallis			Mann-Whitney					
	χ^2	df	<i>p</i>	TD vs ADHD	TD vs LI	TD vs LD	ADHD vs LI	ADHD vs LD	LI vs LD
				<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>
DDT:FR (right)	36.41	3	<0.001	<0.001	<0.001	0.334	0.828	0.005	0.008
DDT:FR (left)	36.01	3	<0.001	<0.001	<0.001	0.003	0.018	0.770	0.043
DDT:SFA (right)	19.65	3	<0.001	<0.001	0.007	0.247	0.532	0.147	0.300
DDT:SFA (left)	25.90	3	<0.001	<0.001	0.009	0.012	0.873	0.301	0.748
mNVRT(n)	22.20	3	<0.001	0.053	<0.001	0.009	0.147	0.441	0.300
eNVRT(n)	22.38	3	<0.001	<0.001	0.016	0.166	<0.001	0.002	0.412

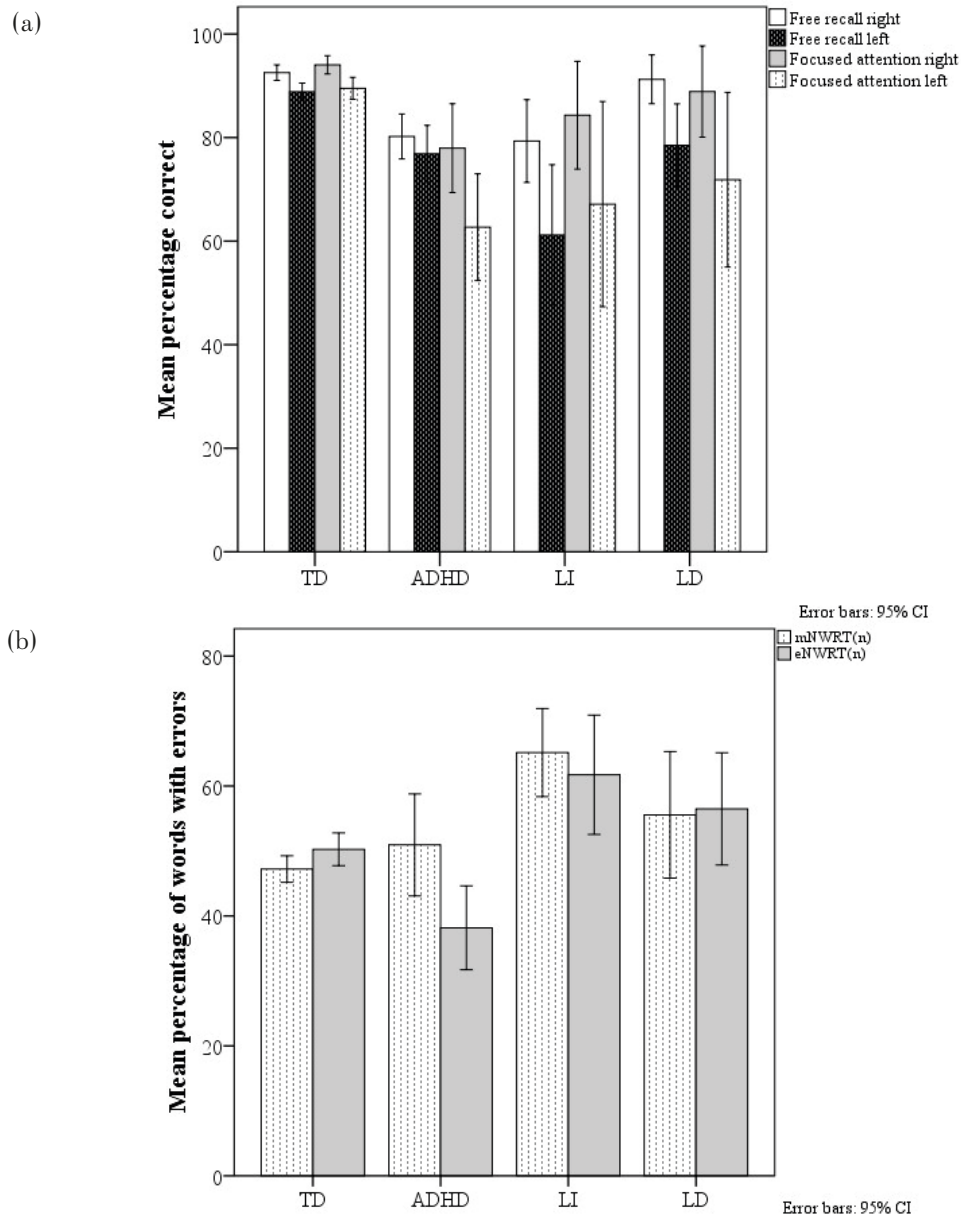


Figure 2. Mean scores obtained from auditory processing subtests using linguistic stimuli: (a) mean percentage correct scores from the DDT subtests (b) mean percentage of words with errors in the Maltese and English NVRTs in noise.

Table 4. Comparison of means in the auditory processing subtests using non-linguistic stimuli

Subtests using non-linguistic stimuli	Kruskal-Wallis			Mann-Whitney					
	χ^2	df	p	TD vs ADHD	TD vs LI	TD vs LD	ADHD vs LI	ADHD vs LD	LI vs LD
				p	p	p	p	p	p
DPT (right)	21.3	3	<0.001	<0.001	0.225	0.094	0.001	0.002	0.365
DPT (left)	7.05	3	0.070	0.437	0.142	0.040	0.103	0.046	0.562
FPT (right)	3.49	3	0.332	0.120	0.762	0.602	0.612	0.140	0.331
FPT (left)	9.49	3	0.023	0.003	0.792	0.602	0.124	0.074	0.552
GIN (right)	0.53	3	0.912	0.671	0.537	0.537	0.674	0.724	0.557
GIN (left)	4.73	3	0.192	0.049	0.374	0.374	0.226	0.914	0.557

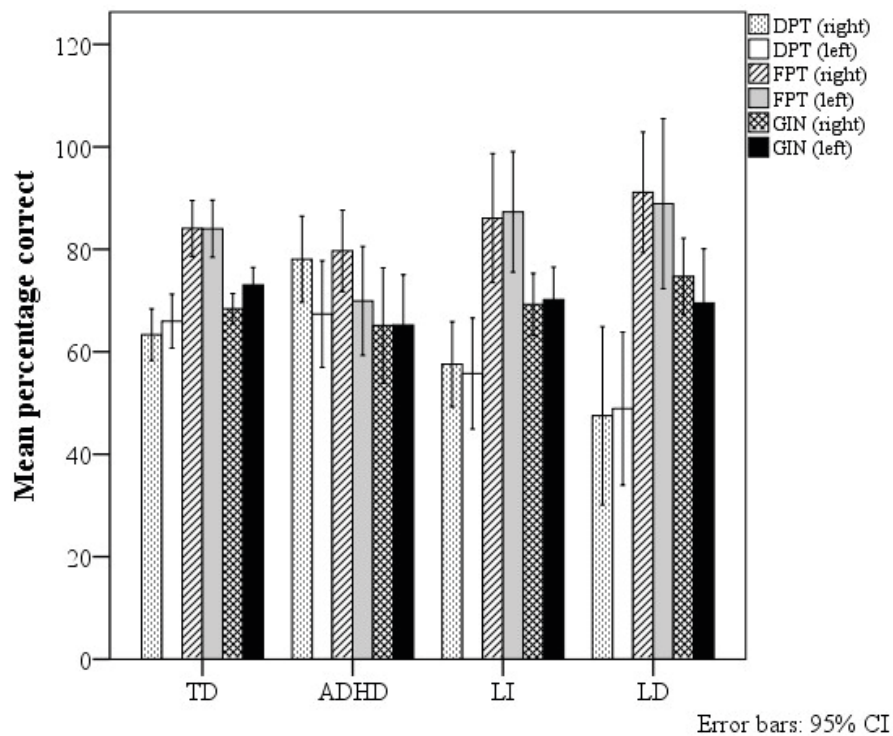


Figure 3. Mean scores obtained from auditory processing subtests using non-linguistic stimuli

Table 5. Comparison of means in the tests of language processing

Subtests using linguistic stimuli	Kruskal-Wallis			Mann-Whitney					
	χ^2	df	p	TD vs ADHD	TD vs LI	TD vs LD	ADHD vs LI	ADHD vs LD	LI vs LD
				p	p	p	p	p	p
SIT	65.59	3	<0.001	<0.001	<0.001	0.008	<0.001	<0.001	0.003
Maltese NWRT(qu)	33.40	3	<0.001	0.758	<0.001	0.005	<0.001	0.010	0.006
English NWRT(qu)	25.88	3	<0.001	0.054	<0.001	0.164	<0.001	0.027	0.012

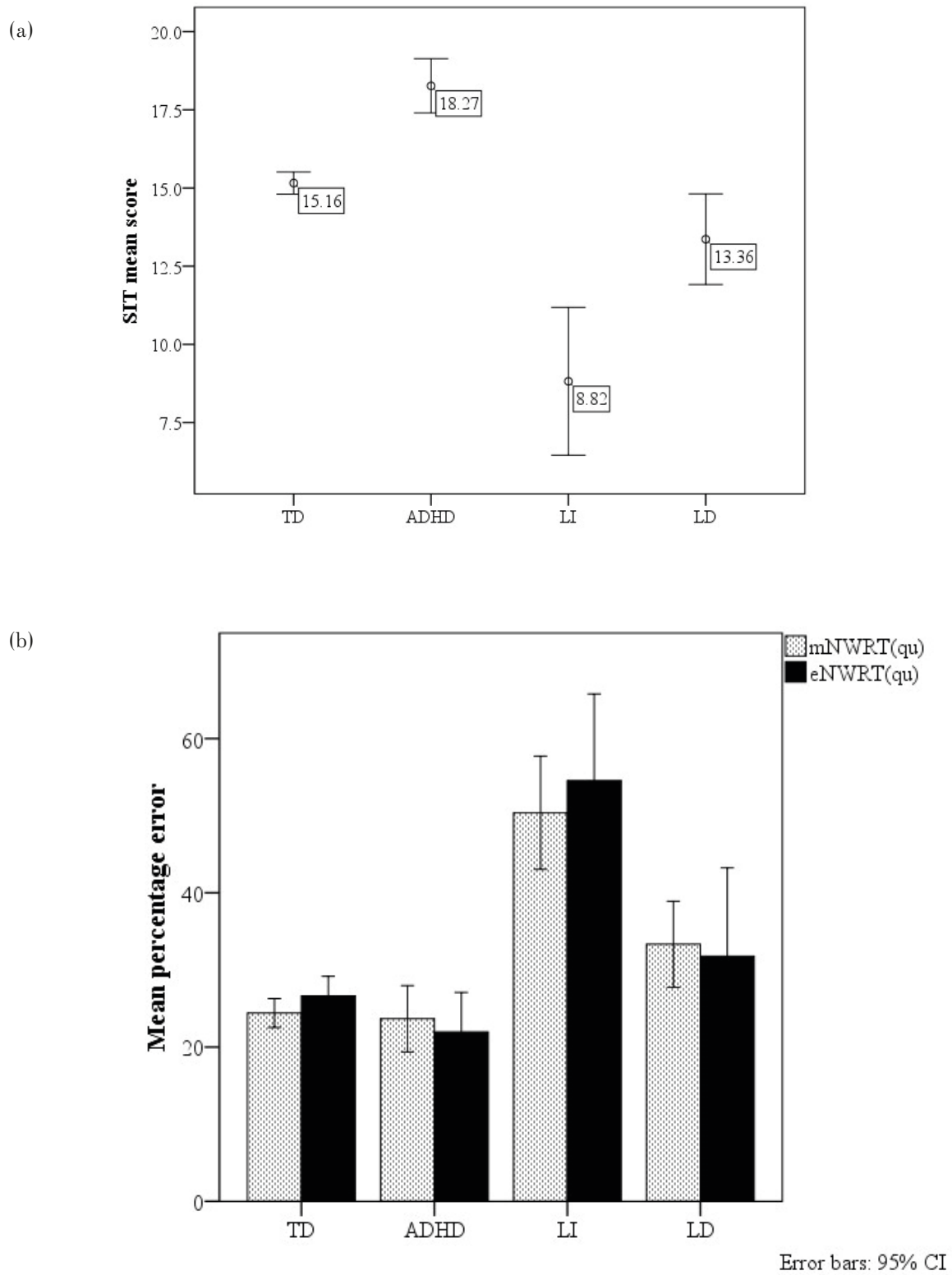


Figure 4. Mean scores obtained from the subtests of language processing: (a) mean scores from the SIT (b) mean percentage of words with errors in the Maltese and English NWRTs in quiet

$r = -0.40, p < 0.001$; left: $r = -0.41, p < 0.001$). Weaker but significant correlations were found with both Maltese-based ($r = 0.24, p = 0.003$) and English-based ($r = 0.18, p = 0.047$) NWRT(n) tests. With regards to the AP subtests with non-linguistic content, significant correlations only emerged in the left ear of two of the subtests: the FPT ($r = -0.21, p = 0.01$) and the GIN ($r = -0.25, p = 0.002$).

3.2 Assessment battery of auditory processing

The auditory processing tests were divided into two main sections following results of an exploratory factor analysis (Tabone, Grech & Bamiou, 2016b): subtests using linguistic stimuli and subtests using non-linguistic stimuli. The former included two DDT and two NWRT(n) subtests, while the latter consisted of the DPT, FPT and GIN tests. Group results were compared for each of the subtests. The Kruskal-Wallis test demonstrated a significant difference between groups in all subtests using linguistic stimuli (Table 3). The TD group performed significantly better than the ADHD and LI groups on all DDTs. When compared with the LD group, a significant difference was observed only in the left ear for both DDT subtests, where the TD group performed better (Figure 2a). Both LI and LD groups revealed better scores obtained from the right ear when compared with the left. This pattern was not so much observed in the TD and ADHD groups.

The Maltese and English NWRT(n) subtests (mNWRT(n) and eNWRT(n) respectively) revealed significant group differences. The ADHD group was found to perform significantly better than all other groups on the eNWRT(n) (Figure 2b) and scored similarly to the TD group on the mNWRT(n). The TD group performed significantly better than the LI group on both NWRT subtests and better than the LD group on the mNWRT(n). The LD group obtained lower mean error scores than the LI group. However, these differences were not statistically significant.

There were few significant differences between groups in the subtests using non-linguistic stimuli (Table 4). Generally, significant differences were evident only in one ear with the exception of the DPT comparison between the ADHD and LD groups, where the ADHD group performed significantly better than the LD group in both ears. The LD group was found to perform weakest in the DPT (Figure 3).

3.3 Tests of language processing

The LI group was found to perform the weakest in all tests of language processing (see Figures 4a and 4b). The difference in performance was significant when compared with all TD, ADHD and LD groups (Table 5). There was no significant difference between the TD and ADHD groups on the NWRT subtests. However, on average the ADHD group performed significantly better than the TD group on the SIT. These two groups were also found to obtain better scores than the LD group on the tests of language processing.

4 Discussion

This study set out to investigate the performance of Maltese children on an array of auditory and language processing tests and draw out comparisons between TD and clinical groups. Participant groups' performance on the specific components of the test battery is discussed next.

4.1 Questionnaire

Parental report through the use of questionnaires is a relatively inexpensive and quick method to document the perceived listening difficulties of children and is commonly used as part of an APD assessment battery (Moore et al., 2012). All clinical groups performed significantly worse than their TD peers on the QCAP, suggesting that children diagnosed with LI, LD and ADHD also tend to exhibit listening difficulties. This result was consistent with studies investigating the listening difficulties of children suspected to present with APD by means of a questionnaire (e.g. Barry et al., 2015; Sharma et al., 2014). Results of this study further showed that the children diagnosed with LI and ADHD were reported as having difficulties in all subdomains of the QCAP. The children with LD did not present with a significant difference from the TD or other clinical groups in the 'social situations' subdomain. This might suggest that the difficulties in social situations exhibited by the children with LD might not be as pronounced as those of the other clinical groups. The results also demonstrated no significant difference between the scores obtained from the different clinical groups, suggesting that parents perceive their children as having similar listening difficulties despite the different diagnoses. This outcome is comparable with that reported by Ferguson et al. (2011), who obtained parental reports on auditory processing, communication skills and attention levels in mainstream school (MS) children and those diagnosed with SLI or APD. Some of the children in each group were also diagnosed with dyslexia, ADHD and autism spectrum disorder. The authors found that overall, the MS children performed better than the clinical groups across all domains. They also found no difference in performance between the clinical groups in communication, auditory attention and memory.

4.2 Assessment battery of auditory processing

The participants in the clinical groups were formally diagnosed by a speech-language pathologist (for LI), and a psychologist (with LD or ADHD). None of them were assessed by an audiologist and were therefore not given a diagnosis of APD. However, all were reported to have listening difficulties despite exhibiting normal hearing – a typical characteristic of APD (de Wit et al., 2016). It is therefore suspected that these children might have also presented with APD.

Dichotic listening tasks are the most frequently used in APD assessment batteries (Cameron et al., 2016) and have been found to correlate substantially with everyday listening difficulties (Tomlin et al., 2015). Nevertheless,

it is now known that dichotic listening relies heavily on cognitive abilities such as attention (DeBonis, 2015), short-term auditory memory, and language skills (Loo, Bamiou & Rosen, 2013). In light of this literature, the findings of this study are not surprising. The DDTs did in fact correlate best with the QCAP, which includes sections on 'auditory attention and memory' and 'conversation skills', and resulted in all clinical groups performing significantly worse than the TD group on the DDTs, either in both or one ear. This result is consistent with previous studies (e.g. Barry et al., 2015; Rocha-Muniz et al., 2014) who found that all children in their clinical groups performed worse than their TD group. Contrasting results were however reported by Sharma et al. (2014), where the children with listening difficulties performed age appropriately on DDTs. It must be noted that the children in the latter study were older than the ones reported in the present study and those by Barry et al. (2015) and Rocha-Muniz et al. (2014), which might indicate that skills in dichotic listening are still developing in younger children as investigated in this study.

Speech-in-noise tests are frequently used as part of APD test batteries (e.g. Moore et al., 2010; Lagacé et al., 2011). These tasks require the listener to recognise the intended speech signal from background noise. It has been suggested that this skill entails both the encoding of frequency and temporal information in the brainstem, and the consequent auditory attention and working memory processes (Anderson et al., 2010), which are needed to excerpt the signal from the noise and facilitate speech understanding (DeBonis, 2015). While some authors claim that the factor underlying the ability of listening in noise is working memory (e.g. Rudner, Rönnberg & Lunner, 2011), others (e.g. Ferguson et al., 2011) propose that attention skills are crucial. The LI and LD children in this study performed significantly worse than the TD group in one or both of the NWRT(n) subtests. The linguistic element present in the stimuli could have been an underlying factor since these groups also performed worse in the NWRT(qu) subtests. NWRT and sentence imitation (SI) have been frequently documented as clinical markers of LI. NWR taps into linguistic processing at a phonotactic level, without any inclusion of meaning (Thordardottir & Brandeker, 2013), while SI displays grammatical abilities, short-term memory and working memory (Riches, 2012). Studies investigating speech in noise using non-word syllables (e.g. Moore et al., 2010; Ferguson et al., 2011), single words (e.g. Rocha-Muniz et al., 2014) and sentences (e.g. Ferguson et al., 2011) suggested that children with suspected APD and comorbid LI tend to perform poorly on non-word and word repetition, but not so much on SI in noise. The emergent findings of SI (in quiet) in this study already resulted in a significantly worse performance by the LI and LD groups in comparison with the TD participants. The ADHD group did not perform significantly worse than the TD group on both NWRT(qu) and SI tasks. This result seems to be in line with previous research (e.g. Redmond, Thompson & Goldstein, 2011), who investigated the performance of children diagnosed with SLI and ADHD on tests of SI and NWR and found no difference in performance between the TD and ADHD groups on both

tasks, but a significant difference with their LI group. It would be interesting to investigate the performance on a SI task in noise in future research on this population. It would be of further interest to investigate the performance across varying levels of noise.

It has also been suggested that 'attention' measures predict performance on speech-in-noise tests (Moore et al., 2010). This finding did not emerge in the current study, where the ADHD group performed well in the speech-in-noise task, despite the reported listening difficulties. A possible reason for this outcome could be the extra time (compared with the TD group) that these children were given to complete the tasks. Although the study could have opted to allocate the same time frame across groups to process all the tasks in the assessment battery, it was of greater interest to investigate the accuracy with which the tasks were completed rather than the speed.

Tallal's (2004) theory of temporal processing suggests that LI occurs due to difficulty in managing sound stimuli presented rapidly. In relation to this, Loo et al. (2013) found poorer gap detection thresholds in children with language difficulties. On the other hand, Sharma et al. (2009) reported that children with comorbid LI and reading disorder performed well on their temporal processing task using the FPT. Rosen, Adlard, and van der Lely (2009) explored claims that non-speech auditory deficits underlie LI but concluded that this is unlikely since a high percentage of their sample with a LI performed within normal limits on tasks of masked thresholds. The results that emerged from the group performances in this study resulted in no significant differences in both ears between the TD and clinical groups on tasks using non-linguistic stimuli. This is in contrast to the subtests using linguistic stimuli where the LI and LD groups performed significantly worse than the TD group. The significant correlations that emerged between QCAP and all the AP subtests with linguistic content suggest that there might be a stronger link between perceived listening difficulties and the performance on complex listening situations that involve language to some extent. A similar result has already been reported. Grube et al. (2014) analysed the relationship between auditory and language processing in children with LD in comparison to TD children. They found no significant differences between the two groups on auditory processing tasks of pitch, rhythm and timbre. The children with literacy difficulties did however perform poorer on phonological language and literacy tasks.

4.3 Limitations

This study included relatively small samples. Considering that to date there are no data on the performance of TD children on auditory processing tests, a larger sample could bring out more robust norms. Larger samples of the clinical groups could allow for better generalisation to the population of children diagnosed with LI, ADHD, and LD. Although this research established criteria to recruit the clinical groups, their initial diagnoses were given by different professionals, resulting in possible variability depending on the diagnostic

tools used. Moreover, the data were collected by different researchers, increasing the chance of variability, despite the stringent scoring rules. A final limitation could be that other newly developed measures of AP not used in this study, such as adaptive speech-in-noise tests instead of set noise levels and alternative tests using non-linguistic stimuli, might have yielded different results. Future studies should address these limitations and include these developments in the investigation of this population.

5 Conclusion

Through parental report, all clinical groups were perceived as exhibiting listening difficulties. The children diagnosed with LI and LD were found to perform significantly weaker on all AP subtests using linguistic stimuli. The children with ADHD exhibited fewer difficulties. While this group performed poorly in the DDTs, no difficulties were evident in the NWRT(n). No significant differences emerged between the TD and clinical groups on tasks using non-linguistic stimuli. This possibly suggests that the listening difficulties exhibited in Maltese children diagnosed with LI, LD and ADHD are mainly specific to linguistic stimuli. However, it would be interesting to carry out further research using other available AP tools to strengthen these claims or otherwise.

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8 Conflicts of interest

The authors report no conflicts of interest.

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Appendix A

QUESTIONNAIRE OF (CENTRAL) AUDITORY PROCESSING

Date: _____

Child's Date of Birth: _____

Age of Child at testing: _____

In each of the 25 statements circle YES or NO, or a number from 1 to 5 according to how relevant each statement is to you (1 = not relevant to 5 = very relevant).

1 The child suffers, or suffered in the past, from ear problems. (Ear problems include: ear infection, earaches, draining ears, medicine taken for ear problems, fluid behind the ear drum, holes in the eardrum, glue ear.)

YES	NO
-----	----

If YES, please describe briefly: _____

2 The child participates or participated in special class(es) or therapies.

YES	NO
-----	----

If YES, please describe briefly: _____

3 The child has been diagnosed with a language impairment, dyslexia, autism or ADHD (attention-deficit/hyperactivity disorder).

YES	NO
-----	----

If YES, please describe briefly: _____

4 The child has suffered from a head injury or epilepsy.

YES	NO
-----	----

If YES, please describe briefly: _____

5 The child was born prematurely.

YES	NO
-----	----

If YES, please describe briefly: _____

6 The child finds difficulty in listening to speech and understanding it.

1	2	3	4	5
---	---	---	---	---

7 The child is sensitive to loud sounds.

1	2	3	4	5
---	---	---	---	---

8 The child gets distracted in noisy places.

1	2	3	4	5
---	---	---	---	---

9 The child finds difficulty in following and/or understanding television programmes.

1	2	3	4	5
---	---	---	---	---

10 The child tends to increase the volume of television or audio equipment when listening.

1	2	3	4	5
---	---	---	---	---

11 The child finds difficulty in following directions with multiple steps.

1	2	3	4	5
---	---	---	---	---

12 The child seems to be a restless person, who finds great difficulty in keeping still.

1	2	3	4	5
---	---	---	---	---

13 The child finds difficulty in attending to a task.

1	2	3	4	5
---	---	---	---	---

14 The child is easily distracted.

1	2	3	4	5
---	---	---	---	---

15 The child can be forgetful, specifically for spoken information.

1	2	3	4	5
---	---	---	---	---

16 In conversation, the child often asks people to repeat themselves.

1	2	3	4	5
---	---	---	---	---

17 The child prefers solitary activities to social activities.

1	2	3	4	5
---	---	---	---	---

18 The child often finds him/herself unable to keep to task deadlines.

1	2	3	4	5
---	---	---	---	---

19 In conversation, the child tends to tilt his/her head towards speakers.

1	2	3	4	5
---	---	---	---	---

20 The child has organisational difficulties that cause problems.

1	2	3	4	5
---	---	---	---	---

21 The child tends to shy away from class discussions.

1	2	3	4	5
---	---	---	---	---

22 The child finds difficulty in following long conversations.

1	2	3	4	5
---	---	---	---	---

23 The child finds his/her telephone conversations frustrating.

1	2	3	4	5
---	---	---	---	---

24 The child finds difficulty in taking notes in class.

1	2	3	4	5
---	---	---	---	---

25 The child finds difficulty in dividing his/her attention.

1	2	3	4	5
---	---	---	---	---

Which language/s does your child feel most comfortable speaking?

English Maltese Both

Commentary

IMPROVING SCIENCE AND HEALTH COMMUNICATION FOR THE MALTESE ISLANDS

Edward Duca

Centre for Entrepreneurship and Business Incubation, University of Malta, Msida, Malta

Abstract. Society faces many challenges worldwide. Decades of science popularisation or health campaigns have not managed to significantly increase science literacy or produce enough Science, Technology, Engineering and Mathematics (STEM) graduates with the right skills; ineffective alternative medicines are now a multi-billion dollar industry while unhealthy diets coupled with a sedentary lifestyle are leading to an increase in obesity, diabetes, cancer and other problems. This commentary gives a generic overview of science and health communication, outlining some of the latest ideas designed to introduce the concepts of dialogue, public engagement, and responsible research and innovation into these fields for more effective approaches. It also suggests that communication campaigns need to be evaluated to assess their effectiveness, and discusses how research funding applications can be improved by involving communication practitioners. In addition, it recommends that Malta needs to create a coordinated public engagement strategy to maximise resources.

Keywords: science communication, health communication, responsible research and innovation, public engagement

1 Introduction: Defining Science and Health Communication

Identifying when science communication started is difficult. The printing press was invented in 1456, launching mass communication, while in 1860, Thomas Henry Huxley gave his famous speech to the Bishop of Oxford, Samuel Wilberforce, defending the theory of evolution (Illingworth, 2015). However, to the author's knowledge, the first mention of 'science communication' in a scientific journal was by Marx in 1965 in *Science*. As used then, the term seems muddled between communication amongst scientists and

the so-called "popular dissemination of science" (Marx, 1965, p. 950). Definitions have plagued the field of science communication for decades, with an attempt to restore order through Burns, O'Connor and Stockmayer's (2003) AEIOU vowel analogy incorporating Awareness, Enjoyment, Interest, Opinion-forming and Understanding into the field. This definition has now been superseded by the concepts of public engagement and dialogue (Faulkner, 2011) and that of Responsible Research and Innovation (RRI) fronted by the European Union (EU), which sees researchers engaging with different stakeholders and involving them throughout the entire research process (New Understanding of Communication, Learning and Engagement in Universities and Scientific Institutions (NUCLEUS) Project, 2016).

How the definitions of science communication have evolved reflects the problems society faces. Worldwide, science literacy has not increased significantly, despite decades of science popularisation (Miller, 1983; Liu, 2009). The number of people still believing in creationism or homeopathy is alarming (Frass et al., 2012; Huskinson et al., 2016; Moore, 2000). Additionally, Europe and countries worldwide are still not producing enough Science, Technology, Engineering and Mathematics (STEM) graduates with the right skills (Caprile et al., 2015). In Malta, the Trends in International Mathematics and Science Study (TIMSS 2011) placed Malta 40th among 50 countries (Ministry for Education and Employment, 2013), while a recent report commissioned by the Malta Council for Science and Technology showed that over half of the Maltese public is disinterested in science (Malta Council for Science & Technology, 2015). This trend was particularly evidenced among individuals who had retired, those who were unemployed, responsible for home duties and/or had a secondary level of education or lower.

The deficit model in science communication has not worked (Miller, 2001). The model paints so-called non-scientists as being empty vessels that need to be filled by the scientific knowledge of researchers and other experts (Miller, 1983). These issues are reflected in health literacy and health communication but with more serious consequences, given that health is life. The earliest scientific reference to health communication appears to have been that by Seidenfeld in 1959, outlining how mass media could be used in health communication. Health communication has been defined

Correspondence to Edward Duca
 (edward.duca@um.edu.mt)

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by the United States Department of Health and Human Services (2000) as the “art and technique of informing, influencing, and motivating individual, institutional, and public audiences about important health issues” (p. 20), with the aim of preventing disease, promoting health, influencing policy and enhancing the quality of life. More recent ideas see renewed hope in surmounting the shortcomings of the deficit model, which sees communication as a one-way model of experts talking to citizens. Multidisciplinary techniques are being encouraged, particularly by combining health communication theory and practice for effective communication processes to change human behaviour (Rimal & Lapinski, 2009). As with science communication, the field is conducting more formative evaluation to see if health communication campaigns actually achieve their goals. Additionally, it has also moved away from the deficit model towards more inclusive models, in particular those that see the social community as a vital component (Parrott, 2004; Rimal & Lapinski, 2009).

The concepts of dialogue and RRI do not seem to have fully infiltrated health communication. Updating definitions of health communication with these concepts is a key opportunity. As part of the EU project NUCLEUS, the author has met several health researchers and fund managers who are already practising some tenets of RRI, notwithstanding the fact that they are not aware of the terminology, in order to have more effective research and community engagement. The aim of this paper is to give a generic overview of science and health communication and outline their relevance for both researchers and civil society, in particular for more effective engagement and research funding applications. It will then offer recommendations to incorporate the concepts of public engagement, dialogue and RRI within research practice and communication campaigns in the Maltese Islands.

2 Health Communication for Better Health

Predicting health behaviour from communication campaigns is highly challenging. Studies need to be conducted for an understanding of the needs of the different audiences within society, so that health campaigns can be tailored accordingly. Belief systems, religious and cultural values, life experiences and group identity are all important considerations that affect how individuals uptake information (Thomas, Fine & Ibrahim, 2004). Health campaigns need to be coupled with formative evaluation to assess their effectiveness, and should involve a multidisciplinary team that can include communication specialists, behavioural scientists, statisticians, health practitioners and public health specialists (Parrott, 2004). Many communication interventions are difficult to randomise, with many challenges for such campaigns, hence the need for a variety of messages developed using a multidisciplinary approach (Rimal & Lapinski, 2009). While demanding, this approach is essential due to the importance of the challenges.

The Maltese Islands, like the rest of the world, are facing many health epidemics, such as obesity, dementia, diabetes and cancer, coupled with longer lifespans, high-calorie diets and a sedentary lifestyle (Commonwealth Health Online, 2016). Misinformation is rife due to the strong financial and emotional campaigns of disproven alternative medicines, such as homeopathy and many Chinese medicines (Australian Government Department of Health, 2015; Ernst, 2002a, b; Ernst, 2006; Hunt et al., 2010; Tang, Zhan & Ernst, 1999, Vogler, Pittler & Ernst, 1999). In addition, health communication is essential in making known the genetic susceptibility to diseases such as cancer and heart attacks, addressing fears on designer babies, genetically modified organisms (GMOs) and new technology like robot-guided surgery, while also providing the right advice to reduce public health issues such as sexual health infections, antibiotic resistance and the abuse of prescription medicines (Buhagiar, 2015; Schwartz & Woloshin, 2013). Health communication can also address misconceptions such as the incorrect link between autism and vaccination (Godlee, Smith & Marcovitch, 2011). Incorporating the concepts of public engagement, dialogue and RRI will result in better research and more effective health campaigns that address cultural sensitivities.

3 Health Communication and the Perception of Risk

The fields of science and health communication are characterised by the use of jargon related to abstract scientific phenomena as well as precise medical terms. The use of jargon by experts results in unnecessary second guessing by citizens (Fischhoff, 2013). Using excessive amounts of scientific terminology can result in more misunderstandings. The opposite is true as well: an absence of scientific content results in no effective communication.

Behavioural science has shown the unreliable nature of intuition. People can exaggerate how widely their own beliefs are shared. This belief, known as the common knowledge effect, is closely linked to the false consensus effect, which involves many people accepting incorrect facts because others hold them (Nickerson, 1999). These compounding factors led to people only partially evacuating the World Trade Centre during 9/11 (Wessely, 2005). In addition, there is the concept of confirmation bias which is observed when new evidence, no matter what it is, is taken as confirmation of one’s pre-existing beliefs. This phenomenon is starkly seen in both politics and climate change denial (Whitmarsh, 2011). Intuition cannot be trusted with public health messages. Communicators need to work with cognitive scientists and other research disciplines to evaluate campaigns and assess their impact to establish if messages are working as desired.

Risk communication is very important in health communication (Rimal & Lapinski, 2009). Communication campaigns need to regularly and clearly convey health risks, be they cancer risks due to lifestyle and food items, or sexual health risks over a prolonged period of time. Human Immunodeficiency Virus (HIV) transmission rates,

for example, are only between 0.060% and 0.015% per sexual encounter, depending on the type of unprotected sex, but with repeated exposure the cumulative risk is almost a certainty (Varghese et al., 2002). Whatever the method of communication (or public engagement), the message needs to be simplified and clarified. Numbers may be replaced with simpler phrases (Budescu, Broomell & Por, 2009; Politi, Han & Col, 2007). A method preferred by the author is the use of natural frequencies. In 2005, several tabloids in the United Kingdom (UK) reported “British research revealed that patients taking ibuprofen to treat arthritis face a 24% increased risk of suffering a heart attack”. The headlines caused a stir, selling papers. Natural frequencies use numbers instead of probabilities. In this case, the natural frequency was one extra heart attack in 1,005 individuals on ibuprofen - definitely not a cause for alarm (Goldacre, 2005). Use of natural frequencies by experts would deliver a clearer message and build trust with citizens. Sensationalist headlines about food items causing or protecting against cancer have resulted in disillusionment in society about nutritional guidelines, a greater push for alternative medicines and fad diets, together with a spread of misinformation.

The above often assumes that individuals respond to risk information, or any information, ‘rationally’. In the rational actor model, experts are there to identify the risk, be it related to the Measles, Mumps and Rubella (MMR) vaccine or sexual health, and convey it based on scientific evidence. Knowledge should be made available. If people have unprotected sex or avoid vaccinating their children, the expert needs to communicate the risks more vigorously. However, history has shown that the approach does not work. The issue is that these messages can be countered by high profile individuals or groups that are more media savvy and strike a key emotional resonance (Reilly, 1999). Citizens do actively seek out information, but can also consciously avoid it if it does not agree with their worldview. The social context in which the information is experienced also reflects the citizen’s response. Additionally, trust of the source and their own personal needs are key. The ‘rational’ model typically does not take these into consideration, meaning that there is little evidence that such a type of communication results in the desired behavioural change that society, health-policy makers and public health experts want (Alaszewski, 2005).

Science communication faces a similar problem, whereby ‘rational’ models do not apply. There are many studies that show that the deficit or ‘rational’ model do not work in risk or science communication, be it about the health risk of GMOs to teenage pregnancy or risk of coronary heart disease in women (Coleman, 2002; Ruston & Clayton, 2002). Patients and citizens from various sectors of the public take an active role in seeking information, and not necessarily just from vetted experts, but friends, family and various online sources. Communication is a two-way process and needs to incorporate the concerns of patients. This requires time and compassion that can be difficult in stressful public health scenarios. The concept of dialogue to support a framework of public engagement and RRI is critical to more effective research and communication campaigns.

There is some good news. Citizens want to hear about science and health from experts, not journalists or politicians. There is still public trust in experts, according to the Wellcome Trust Monitor (Huskinson et al., 2016). Individuals in the UK showed the following trust ratings: doctors or nurses - 64%; university scientists - 59%; journalists - 3%. A similar trend is seen in science communication (Castell et al., 2014), with individual scientists trusted much more than politicians, journalists or even funding institutions. Citizens want university scientists and professionals to speak up, rather than industry, journalists or government officials. Professionals and researchers should communicate the messages themselves.

Health communication has an added layer of complexity as people can trust or mistrust a profession due to personal experiences. However, individual trust is vital as well. Individuals give particular credibility to sources that they know, which may include family and friends but also medical advisers. Being a doctor is not good enough; the person must be a doctor whom the individual knows and trusts (Frewer & Miles, 2003).

4 Conclusion: The Role of Health Communication in Responsible Research and Innovation (RRI) and in Winning Funding

Personal observations derived through participation in the NUCLEUS project suggest that health practitioners in the United Kingdom are already consulting the public on research, although the extent and depth to which this may be taking place is unclear. The UK National Institute for Health Research expects applicants to show evidence of public consultation in funding applications to ensure impact, which ties in with the concept of involving society to inform research questions from the very start (National Institute for Health Research, UK, 2016). This approach is shared with Horizon 2020’s RRI push. RRI is also meant to engage society to inform research questions, although for the EU it also means upholding the pillars of public engagement, open access, gender, ethics and science education (European Commission, 2016). Not all communicators agree with these pillars, fearing they might just become a box-ticking exercise rather than real engagement with the public.

The good news is that the EU is pushing more funding into scientific research in relation to society, including both science and health communication. In addition, every research project is expected to disseminate its research findings. An opportunity presents itself to include professional science communicators when applying for funds (not just to disseminate results). Although not scientifically quantified, the approach of having funding application sections dedicated to public engagement and RRI would show that the project is serious about communication from its outset, therefore enhancing application success. Engagement should not be performed just at the end of a project.

In Malta we need more public engagement in science and health communication to address both socio-economic development and public health campaigns (Malta Chamber of Scientists, 2016). For this to happen, more researchers and health practitioners need to engage the public with their work. The University of Malta (UoM) could either set up some form of institute, centre or unit as a one-stop shop to empower researchers and evaluate their needs, or adopt a decentralised approach that sees communication specialists in every academic structure at UoM, or adopt a mix of both. The specialists would need to work with many other disciplines while also having a structure that combines communication theory and practice. The communication campaigns they create would need to be evaluated, ideally independently, to assess their effectiveness. Such a process would help incorporate public engagement and RRI as a pillar of Malta's higher education institution.

The Maltese Islands' small size is an opportunity for rapid and effective communication campaigns. A coordinated public engagement strategy that includes all stakeholders is feasible. Such a nationwide strategy would be very efficient in changing health behaviours in Malta, thus helping to mitigate the rising problems of diabetes and obesity, among others, that the country faces. A small competitive public engagement fund specific to Malta or, even better, tapping of EU funding, could also go a long way. A sustained public engagement effort, that addresses many different parts of society and their individual needs, could help attract more research funds to Malta while improving public health and the quality of life.

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6 Conflicts of Interest

The author reports no conflicts of interest.

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Short communication

RISK FACTORS FOR SELF-HARM IN CHILDREN AND ADOLESCENTS ADMITTED TO A PSYCHIATRIC HOSPITAL IN MALTA

Anton Grech, Sally Axiak

Mount Carmel Hospital, Attard, Malta

Abstract. The aim of this research was to identify risk factors for self-harm amongst the total population of children and adolescents admitted to an in-patient psychiatric hospital over a five-year period. A retrospective audit of patient records ($N = 212$) covering 2010 to 2014 (both years included) showed that approximately 38% of all children and adolescents who were in-patients at the psychiatric hospital during the study period harmed themselves prior to admission. Male gender was found to be associated with self-harm. Results also suggested that family factors, specifically living with a single parent, significantly added to the risk of self-harm amongst the study population. Although the findings revealed that being male and hailing from a single-parent family are significant risk factors for self-harm in Maltese children and adolescents, this study did not establish why this is the case, therefore suggesting the need for further research. A prospective, longitudinal design would assess predictors of self-harm more clearly. Furthermore, self-reports would increase accuracy and reduce third-party reporter bias, while permitting more in-depth exploration of the risk factors involved in child and adolescent deliberate self-harm.

Keywords: Malta, self-harm, psychiatry, child, adolescent

1 Introduction

The Maltese Islands are situated in the central Mediterranean Sea and have the lowest total population of any European Union Member State, estimated to be approximately 425,000 in the 2011 National Census (National Statistics Office, 2012). In recent years, strategic planning and policy makers have acknowledged that mental health is an area which requires major development and investment in order to bring

services in line with the present international standards for good practice in the field. However, Malta lacks precise data regarding mental disorder amongst the population in general and, more specifically, regarding factors related to the uptake of psychiatric services by children and adolescents (Grech & Axiak, 2015). Although national Child and Adolescent Mental Health Services (CAMHS) operate from a range of settings, there is only one psychiatric hospital which serves the population of Malta.

1.1 Background

In Europe, deliberate self-harm (DSH) is a commonly used, broad term for self-injurious behaviours, inclusive and exclusive of those with non-fatal suicidal intent (Hagell, 2013). In the United States, the term non-suicidal self-injury (NSSI) is employed to describe self-injurious behaviours that exclude suicidal intent. In a systematic review of global empirical studies reported between 2005 and 2011, Muehlenkamp et al. (2012) reviewed research on all possible types of self-harm, focusing on 11-18-year-olds in community and school settings. Across all the studies, mean lifetime prevalence was 18% for NSSI and 16% for DSH. However, the authors noted that varying estimates of prevalence are attributable to disparate definitions of DSH and NSSI and also to incongruent research methodologies. Hagell (2013) seemed to concur with the latter point in noting that a shortage of reliable data such as that collected through self-reporting may be both misleading and inaccurate. Hjelmeland and Grøholt (2005, p. 64) stated that the rate of self-harm amongst adolescents “is higher than the average rate for the total population in most Western countries, especially among females”. The latter statement was borne out by a prolific comparative community study conducted in seven different countries which encompassed self-reports of over 30,000 adolescents, with findings revealing deliberate self-harm to be twice as common amongst females as males (Madge et al., 2008). Hjelmeland and Grøholt (2005) noted that the reason for incidence being higher in females is as yet an unanswered question. However, they did propose that a number of circumstances associated with adolescence may

Correspondence to Anton Grech

(anton.grech@gov.mt)

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be influential in the high rate of self-harm amongst this age group, including the arbitrariness of adolescence, lack of life experience, impulsiveness and cognitive immaturity. In a comparative study which considered self-harm amongst adolescents compared to self-harm amongst adults, these authors found that while increasing age, female gender, a history of trauma and a diagnosis of depression are well-known risk factors for self-harm, their results confirmed that family factors, in particular living with a step-parent, significantly added to the risk (Hjelmenland & Grøholt, 2005). A study conducted by de Kloet et al. (2011) aimed to identify risk factors for self-harm for children and adolescents in a mental health in-patient unit in Australia. This study identified several factors that increased the likelihood of self-harm, including a diagnosis of depression, female gender, increasing age, living with a step-parent and having family problems. Brent (2011), in an editorial discussing prevention of self-harm in adolescents, claimed that risky health behaviours, including self-harm, are less likely to occur in the presence of a strong parent-child bond and consistent parental supervision. This view is supported by the findings of a study conducted by O'Connor, Rasmussen and Hawton (2014), which addressed risk factors for self-harm amongst school children in Northern Ireland. In this study, boys and girls who reported having self-harmed shared common characteristics, which included not living with both parents, parents who divorced, some degree of substance abuse, mood and personality factors and a history of physical and sexual abuse.

In view of the paucity of research available locally, the central aim of the present study was to establish reliable, baseline information to inform strategic planning and organisation of future CAMHS that reflect Malta's unique needs.

2 Methods

A retrospective survey of patient case notes was undertaken so as to provide a national snapshot of the socio-demographic characteristics of CAMHS users and details regarding their contact with, and uptake of, in-patient psychiatric services. The prevalence of child and adolescent self-harm in Malta and its associated factors are unknown. This paper reports on just one dataset that stemmed from the survey, namely risk factors of self-harm.

2.1 Sampling methodology

The study was based on data from a convenience sample, namely all children and adolescents ($N = 212$) who were in-patients at Malta's only psychiatric hospital between 1st July 2010 and 31st July 2014 (both years included). A data gathering instrument was developed in order to conduct systematic evaluation and verification of factors related to the total population of child and adolescent in-patients during the five-year period. The data gathering instrument included 46 data points, with information mined from the patient records ranging from basic demographics, to

diagnosis, medication, length of stay and reported instances of self-harm (Grech & Axiak, 2015). Data for this study was extracted from the data point related to self-harm. Instances of self-harm were recorded whenever case notes indicated an observed or reported deliberate self-injury prior to admission. The data did not reveal the presence or absence of suicidal intent.

2.2 Ethical approval

This research study is based solely on secondary data mined from records and did not involve any human interventions. Permission to access records was sought from and given by the Data Protection Controller at the institution where the research was conducted.

2.3 Statistical analysis

Risk factors associated with adolescent self-harm were modelled through the technique of logistic regression using SPSS statistical software. Regression methods have become an integral component concerned with describing

Table 1. Diagnosis on admission

Diagnosis on admission	Count	%
Hyperkinetic Disorder	11	5.2
Conduct Disorder	46	21.7
Tic Disorder	2	0.9
Depressive Disorders	20	9.4
Anxiety Disorders	7	3.3
Eating Disorders	2	0.9
Personality Disorders	5	2.4
Developmental Disorder	5	2.4
Schizophrenia/Schizoaffective Disorder	12	5.7
Attention Deficit Hyperactivity Disorder	5	2.4
Obsessive Compulsive Disorder	2	0.9
Autistic Disorder	1	0.5
Conversion Disorder	1	0.5
Adjustment Disorder	1	0.5
Intellectual Disability	5	2.4
Drug-related Disorder	1	0.5
Other	20	9.4
Information not available	66	31.1

the relationship between a response variable and one or more explanatory variables. In the case where the response variable is measured on a binary scale (Yes, No), the regression method of choice is the binary logistic (Rathnayaka, 2008). The binary response variable in this study was Self-harm, which consisted of two levels: 1 was Yes and 2 was No. The last category of the response variable (No) was set to be the reference category. The response variable Self-harm was related to four predictors, namely Gender, Ethnicity, Family Structure and Substance Abuse. Gender was a factor with two levels (Males, Females), Ethnicity was a factor with two levels (Foreigner, Maltese), Family Structure was a factor with two levels (One-parent, Two-parent) and Substance Abuse was a factor with two levels (Yes, No). These predictors were all included as main effects in the model fit and the last category of each predictor was aliased (set to 0).

3 Results

During the period under study there were 212 child and adolescent admissions to the psychiatric hospital. Of these, 121 were males and 91 were females. Diagnosis on admission was distributed as indicated in Table 1.

Table 2. Risk factors for self-harm with their corresponding degrees of freedom and *p*-values

Risk factors	Chi-square	Degrees of freedom	<i>p</i> -value
Gender	6.112	1	0.013
Ethnicity	11.565	1	0.001
Family Structure	3.852	1	0.049
Substance Abuse	7.971	1	0.005

Within the total number of 212 admissions, there were 80 reported cases of self-harm prior to admission (approximately 38% of total admissions). There were no reported incidences of self-harm in any patient under 10 years of age. The majority of cases were aged between 14 and 17 years (76%). The distribution of cases by age is shown in Figure 1.

Since it was of interest to check whether various factors usually associated with adolescent self-harm were associated with an individual in the study sample being a self-harm case or not, a Chi-Square test of Independence was carried out for each of the risk factors as a preliminary analysis. Table 2 lists various risk factors for self-harm with their corresponding degrees of freedom and significance values. All risk factors were found to have a *p*-value less than the 0.05 level of significance, which shows that they all had a significant association with self-harm.

Risk factors were then analysed through the use of binary logistic regression. Table 3 shows the parsimonious model, which includes two significant main effects (Gender and Family Structure) since their corresponding *p*-values were less than 0.05. Gender was the best predictor of the response

Table 3. Variables in the logistic regression model

Variables	Parameter estimates	Degrees of freedom	<i>p</i> -value	Odds ratio
Gender (Male)	1.118	1	0.004	3.059
Gender (Female)	0 (aliased)			
Family Structure (One-parent)	0.799	1	0.038	2.223
Family Structure (Two-parent)	0 (aliased)			
Constant	0.165	1	0.587	1.180

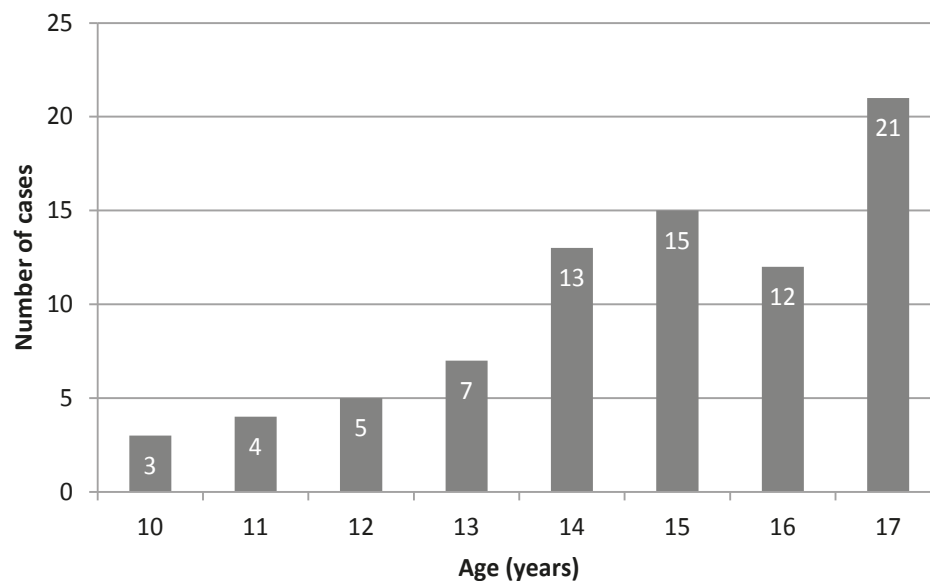


Figure 1. Distribution of cases by age

outcome (Self-harm) since it had the smallest p -value (0.004).

Ethnicity and Substance Abuse were found to be weak predictors since their p -values (0.427 and 0.247 respectively) exceeded the 0.05 level of significance. These predictors were removed from the model fit since their contribution in explaining variation in the response outcomes was negligible.

Variable selection for identifying the parsimonious model in all attempts was based on the stepwise procedure. This involves entering the variable that has the strongest positive or negative correlation with the dependent variable into the model and at each subsequent step, adding the variable with the strongest partial correlation. With the stepwise procedure, variables are tested at each step for removal on a 0.05 level of significance and are re-entered on a 0.01 level of significance. This procedure continues until there are no further variables that make worthwhile additional contributions to the fit of the model.

The binary logistic regression model when the outcome is Self-harm (Yes) is:

$$\ln\left(\frac{p}{1-p}\right) = 0.165 + 1.118x_1 + 0.799x_2$$

where p represents the probability that an adolescent engages in self-harm given the predictors x_1 and x_2 representing Gender and Family Structure. $x_1 = 1$ for male and $x_1 = 0$ for female adolescents; $x_2 = 1$ for a single-parent and $x_2 = 0$ for a two-parent family structure.

The parameter estimate for males (1.118) was significantly larger than 0, which indicates that males were more at risk for self-harm than their female counterparts. The odds ratio for Gender (Male) was 3.06. Hence, the odds that male adolescents inflict self-harm was 3.06 times higher than females. On the other hand, the parameter estimate of single-parent family structure (0.799) was significantly larger than 0, which implies that those living in a one-parent family were more at risk for self-harm than their counterparts who lived in a two-parent family. The odds ratio for Family Structure (One-parent) was 2.223. Hence, the odds that adolescents living with one parent inflict self-harm was 2.223 times higher than adolescents living with two parents.

4 Discussion

This study found that approximately 38% of all children and adolescents who were in-patients at the psychiatric hospital during the study period harmed themselves prior to admission. In common with the extant literature (de Kloet et al., 2011; Hjelmeland & Grøholt, 2005; Madge et al., 2008), gender was found to be associated with self-harm. However, our results paradoxically indicate that in this study, males were more likely than females to self-harm. This finding varies from that obtained in other similar studies, which suggest that self-harm is less likely to occur in males than females (Brent, 2011; O'Connor, Rasmussen & Hawton, 2014). Furthermore, it was demonstrated that, in line with the findings of O'Connor, Rasmussen and Hawton (2014), living with a single parent significantly added to the risk of self-harm amongst our study population. Whilst it

is possible to postulate reasons for these associations, they are clearly factors which require further research in order to better understand and predict the risk of self-harm amongst this specific group.

4.1 Limitations

These findings need to be considered in the light of certain limitations. The main limitation of this study was a reliance on generalised data which prevented a more rigorous approach to analysis from being employed. The data collection tool only recorded the incidence of self-harm and did not delve into specifics such as number of instances or types of self-harm. Moreover, the strength of having access to the records of the total population of in-patients in the period surveyed was negated somewhat by incomplete records. Furthermore, there are currently no comprehensive electronic patient information systems available within mental health services in Malta and all data was mined from predominantly handwritten entries in patients' medical and nursing notes. Consequently, the data gathering process was laborious and time-consuming (taking around 12 weeks) and rendered the findings liable to human error and researcher interpretation.

5 Conclusion

Population-based studies on early precursors of deliberate self-harm are key for preventive, clinical and research purposes. In view of the paucity of local research, this small, exploratory study sought to report initial empirical data on the incidence and predictive factors of self-harm within the local context. Whilst the findings have revealed that being a male and hailing from a single-parent family are significant risk factors for self-harm in Malta, it has not sought to establish why this is the case. Therefore, this study supports the need for further research, ideally of a prospective, longitudinal design, in order to clearly assess predictors of self-harm. Furthermore, self-reports would increase accuracy, reduce third-party reporter bias and permit more in-depth exploration of the risk factors involved in child and adolescent deliberate self-harm.

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7 Conflicts of interest

The authors report no conflict of interest.

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