



Original research article

Living with nuclear energy: A systematic review of the psychological consequences of nuclear power

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ABSTRACT

Psychological aspects of living with nuclear energy and technology have interested researchers since their inception, yet a review of the research to date is yet to appear. Following an historical overview of the literature highlighting general thematic and methodological trends, this paper reports on a systematised review of qualitative and mixed methods research on psychological aspects of living with nuclear energy and technology. The historical overview shows how early studies focused on the psychological impacts of the atomic bombs, and living with the spectre of nuclear war. Later research often explored psychological aspects of living with civilian technologies such as nuclear power, and was typically quantitative in approach. Recently, the qualitative and mixed methods literature has expanded. In our systematised review, 26 qualitative and mixed methods studies were found to report on psychological experiences such as living near nuclear power plants and living through a nuclear accident, with common themes described including a lack of trust in authorities, the importance of biography in constituting psychological experience, and factors such as familiarity and sense of place in mediating perceptions. The literature as a whole points to the need for further qualitative research in the area, including more in-depth approaches.

1. Introduction

The discovery and technological applications of nuclear energy have shaped the course of modern history. Following the atomic bombings of Hiroshima and Nagasaki, humans have lived with the global proliferation of nuclear weapons and the threat of nuclear war; nuclear power has been associated with serious accidents and long-lived radioactive waste. Nuclear power continues to be of major contemporary significance, proposed as having a key role to play, alongside renewable sources, in a future of climate change and the critical importance of moving towards a low-carbon energy economy. It is no surprise then that nuclear energy and technologies have been the focus of much psychological research.

Following a brief discussion of qualitative approaches to researching psychosocial aspects of the nuclear realm, an historical overview of the peer-reviewed literature in relation to the human experiences of nuclear energy and technology will be provided. This overview demonstrates the rationale for the following systematised

review of the qualitative literature on civilian nuclear technologies.

1.1. Situating the systematised review

A comprehensive account of the psychological aspects of living with nuclear energy and technology is yet to be published. General trends in the literature indicate that early research focused on exploring the impacts of nuclear energy's early military applications and subsequent developments, that is, the proliferation of nuclear weapons, and the spectre of large scale nuclear war. Later research shifted towards public attitudes and risk perception in relation to nuclear power, including the specific psychological experiences of certain groups, such as people living near nuclear power stations, or people affected by proposed nuclear waste repository siting. The later research also addressed perceptions of potential and actual nuclear accidents including Chernobyl, Three Mile Island (TMI) and Fukushima.

Early research on military applications was often non-data based, whilst quantitative approaches have predominated in the later research

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on civilian applications of nuclear energy and their adverse consequences. More recently, qualitative and mixed methods approaches have increasingly appeared. A more detailed overview of the literature now follows to further demonstrate historical trends in thematic focus and methodological approach.

1.2. The nuclear story

Although not a psychological investigation, Weart's [1,2] seminal works on the cultural history of nuclear energy and technology deepen our understanding of their psychological aspects. Weart argues that latent psychological meanings, often in symbolic form, pre-dated the discovery of nuclear fission. Early physicists who discovered transmutation seemed to experience this in a quasi-spiritual way – as if having discovered the philosopher's stone. Moreover, at the very first atomic bomb test at Trinity, Oppenheimer invoked religious discourse, seemingly experiencing himself as having god-like powers.

Weart documents the entire nuclear story, including the atomic bombings of Japan; the Cold War and nuclear proliferation; the beginnings of civilian nuclear power; the occurrences of nuclear accidents; the ambivalence surrounding the so-called nuclear renaissance; and our current concerns around nuclear terrorism. Weart's cultural history illuminates the importance of psychological subjectivity and meaning-making, pointing towards a deep psychological meaning, a nexus that transcends the nuclear phenomenon itself.

The following question arises: To what extent has the peer-reviewed literature interrogated subjectivity and psychological meaning in relation to nuclear energy and technology?

1.3. Rationale and aims

This paper has two overarching aims. Firstly, to provide an historical overview of the literature in relation to psychological experiences nuclear energy and technologies, across all groups of research participants. This will identify thematic and methodological trends over time, point to gaps in the literature, and consider how the literature has been impacted by calls for subjective accounting. Secondly, we wish to provide the first systematised review of the qualitative psychological literature in relation to civilian applications of nuclear energy and technology. We focus in the systematised review on "civilian" applications, as opposed to "military" applications, the latter being applications specifically intended for military use, and identifiable as such – nuclear weapons, and the broader spectre of nuclear war.

Under the umbrella of "civilian" applications we include studies focusing on experiences of nuclear reactors, nuclear power, and the adverse consequences of these, including nuclear accidents and nuclear waste; we also cover less obvious civilian applications such as nuclear medicine and food irradiation. The aim of this broad investigation of nuclear phenomena is to hopefully converge on what might be the essence of the human experience of nuclear energy and technology in a phenomenological sense.

We explore the psychological literature across all groups of research participants, including members of the public who experience nuclear power and radiation in a general sense, those living near nuclear power stations or proposed nuclear waste sites, and those impacted by nuclear accidents, anti-nuclear activists, and other groups such as community leaders, and nursing professionals.

The resulting systematised qualitative review offers an important contribution to the published literature, at the same time, implying directions for further research.

2. Materials and methods

2.1. Initial search procedure

An initial broad search was conducted using *Embase*, *Google Scholar*,

Table 1
Concept and Search Terms Employed in Initial Search.

Concept	Search Terms
Nuclearity	"nuclear power" OR "nuclear technology" OR "nuclear war" OR "nuclear bomb" OR "nuclear waste" OR "nuclear plant" OR "nuclear accident"
Psychological Factors Experience/ Perception	attitude* OR emotion* OR bias OR "psychological factor" Experience* OR perception*

Proquest, *PsyInfo*, *SCOPUS*, *Sociological Abstracts* and *Web of Science*, to identify available literature on the psychology of all aspects of nuclear energy and technology. Search terms were agreed upon by two researchers (the first and fifth authors) and an academic librarian. **Table 1** shows the concept categorisation and search terms:

The research concept of "nuclearity" was developed to encompass all phenomena of an essentially nuclear nature, both military and civilian, such as nuclear power, nuclear weapons, nuclear waste, and nuclear accidents. To capture studies addressing the experiences and perceptions people have of nuclear phenomena, the concepts of "experience/perception" and "psychological factors" were employed.

2.2. Inclusion criteria for the historical overview

The titles and abstracts of each identified record were assessed according to the following inclusion criteria: the publication was peer-reviewed, addressed psychological/experiential/perceptual aspects of nuclear phenomena, and was written in English. Records published only in languages other than English, with no professional translation readily available, were not included (however, in the results sub-section 3.2.1, below, we summarise key characteristics of two studies only available in a language other than English, which were tagged and met further criteria for the systematised qualitative review).

All identified records were then classified by abstract into "Qualitative/Mixed", "Quantitative" and "Other Non-Data Based" groups. Records with a military focus were then extracted from each of the three groups and classified as "Military – All". This classification was later used to chart historical trends in major themes and methodological approaches over time.

2.3. Inclusion and exclusion criteria for the systematised qualitative review

For the purposes of the qualitative review, qualitative research was defined as research that investigates phenomena in their natural settings, by describing and/or interpreting meanings people give to them. It encompasses a diversity of data gathering techniques – interviews (unstructured, open-ended or semi-structured), participant observation, focus groups, and document analyses. Other qualitative approaches are embedded in a number of different theoretical and methodological frameworks, such as, case studies, ethnography, phenomenology, grounded theory, action research, content analysis, and others [3]. Mixed methods approaches were defined as those that incorporate both qualitative and quantitative components (see [4]).

In the initial categorisation, military records were excluded to permit a focus on civilian nuclear technologies. Then "Qualitative/Mixed" records in agreement between the first and fifth authors were assigned into a "Final for Review – Qualitative/Mixed" group. Records categorised as "Qualitative/Mixed" not in agreement were examined in more detail by the first author; those confirmed to be qualitative or mixed were also assigned "Final for Review – Qualitative/Mixed".

In the final stage, all other records originally excluded as "Quantitative" and "Non-Data Based" were re-examined by methodology to ensure qualitative or mixed studies had not been missed. These were re-assigned accordingly. Upon reviewing the resulting publications selected, it was then decided that studies employing

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