Creating expectations: The bioethics of genetics as reflected in selected South African media with specific reference to CRISPR-Cas9

by

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Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the owner of the copyright thereof (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Date: March 2020

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part, submitted it at any university for a degree.

Date: March 2020

Anna Elizabeth Rademan

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Abstract

In the era of genetic engineering, the CRISPR-Cas9 system has been hailed as one of the most important genetic discoveries and is often discussed in terms of its momentous potential applications on health. However, from a bioethical perspective, the technology poses several challenges with regards to safety, regulation and human enhancement. The field of genetic engineering and bioethics have moved from academic journals to the mass media. The news media's reporting on complex bioethical issues such as CRISPR-Cas9 can influence the public's perception and understanding thereof. Literature confirms that the news media, as part of the public domain, also shape subsequent ethical policies and regulations. Therefore, this study aims to investigate expectations that the South African media create surrounding the CRISPR-Cas9 gene-editing system. In the South African context, academic research in this area is still limited. Situated in the field of journalism studies, this study used a combination of qualitative and quantitative content analysis of CRISPR-Cas9 related articles from the top 10 most popular South African news media sites between January 2013 and June 2019. The study extended knowledge in the field of science and bioethics reporting in the South African news media. Certain problems were observed with regards to evidence-based science journalism as not enough attention was given to specific research applications or methodological aspects of CRISPR-Cas9 and therefore it is difficult for the audience to separate science hype from evidence-based research. The bioethical debate is evident in the articles analysed and showed the tension between the promotion of science but also the caution towards the risks of CRISPR-Cas9. These risks include technical, ethical, legal, and social aspects that need to be addressed before it will be ethically acceptable to use the technology on the human germline. The media play a pivotal part in facilitating the public debate and encouraging public discussion about the governance of the technology. The theory of framing played an important role, and the use of frames can be useful as an aid to explanation and creating cultural and social meaning. However, the choice of frames should be carefully considered because they may misrepresent and mislead public perception of the technology. The news media should perhaps not resurrect old frames such as the Frankenstein myth but instead develop new meaningful metaphors together with evidence-based science journalism.

Opsomming

In die era van genetiese redigering word die CRISPR-Cas9 tegniek beskou as een van die belangrikste genetiese ontdekkings en word gereeld bespreek in die konteks van potensiële belangrike toepassings op gesondheid. Uit 'n bio-etiese perspektief het die tegnologie egter verskeie uitdagings met betrekking tot veiligheid, regulering en onderwerpe soos ontwerpersbabas. Die veld van genetiese redigering en bio-etiek is van akademiese vaktydskrifte oorgedra na die massamedia. Die nuusmedia se verslaggewing oor ingewikkelde bio-etiese kwessies soos CRISPR-Cas9 kan die openbare persepsie en begrip daarvan beïnvloed. Literatuur bevestig dat die nuusmedia as deel van die publieke domein etiese beleide en regulasies kan vorm. Daarom is dit hierdie studie se doel om verwagtinge wat die Suid-Afrikaanse media rondom die CRISPR-Cas9 tegnologie skep, te ondersoek. In die Suid-Afrikaanse konteks is akademiese navorsing op hierdie gebied steeds beperk. Hierdie studie, geleë in die veld van joernalistieke studies, het tussen Januarie 2013 en Junie 2019 'n kombinasie van kwalitatiewe en kwantitatiewe inhoudsanalise van CRISPR-Cas9-verwante artikels van die top 10 gewildste Suid-Afrikaanse nuusmedia-webwerwe gebruik. Die studie het kennis in die gebied van wetenskap en bio-etiekverslaggewing in die Suid-Afrikaanse nuusmedia uitgebrei. Sekere probleme is waargeneem met betrekking tot bewysgebaseerde wetenskapjoernalistiek, omdat daar nie genoeg aandag gevestig is op spesifieke navorsings-toepassings of metodiek van CRISPR-Cas9 nie, en daarom is dit moeilik vir die gehoor om oordrewe wetenskap van bewysgebaseerde navorsing te skei. Die bio-etiese debat kan duidelik gesien word in die geanaliseerde artikels en dui op spanning tussen die bevordering van wetenskap en die risiko's van CRISPR-Cas9. Hierdie risikos sluit tegniese, etiese, wetlike en sosiale aspekte in wat aangespreek moet word voordat dit eties aanvaarbaar is om die menslikegenoom te redigeer. Die media speel 'n belangrike rol in die fasilitering van die openbare debat asook die aanmoediging van gesprekke oor die regulering van die tegnologie. Die raamwerkteorie het 'n belangrike rol gespeel in die studie. Die gebruik van rame kan nuttig wees om die tegnologie te verduidelik en kulturele en sosiale betekenis te skep. Die keuse van rame moet egter noukeurig oorweeg word, omdat dit die openbare persepsie van die tegnologie verkeerd kan voorstel en lesers mislei. Die nuusmedia moet eerder nie ou rame soos die Frankenstein-mite gebruik nie, maar eerder nuwe betekenisvolle metafore ontwikkel saam met bewysgebaseerde wetenskapsjoernalistiek.

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List of abbreviations

AIDS: Acquired immunodeficiency syndrome

CCR5: C-C chemokine receptor type 5

CFTR: Cystic fibrosis transmembrane conductance regulator

CIOMS: Council for International Organizations of Medical Sciences

CRISPR-Cas9: Clustered Regularly Interspaced Short Palindromic Repeats-CRISPR associated protein 9

cRNA: CRISPR-Ribonucleic acid

DMD: Duchenne muscular dystrophy

DNA: Deoxyribonucleic acid

eNCA: eNews Channel Africa

EWN: Eyewitness News

gRNA: guide-RNA

HFEA: Human Fertilisation and Embryology Authority

HIV: Human immunodeficiency virus

IOL: Independent Online

IVF: in vitro fertilisation

PGD: pre-implantation genetic diagnoses

SLC39A8: Solute carrier family 39 member 8

tracr-RNA: trans-activating crRNA

UNESCO: United Nations Educational, Scientific and Cultural Organisation

WHO: World Health Organisation

WMA: World Medical Association

Chapter 1: Introduction

1.1 Background and rationale

From the dawn of genetic research, genes have been an aid to understanding biological life; now our advanced understanding of genetics is allowing us to alter biological life— an astonishing and alarming prospect (Coller, 2019: 289; De Araujo, 2017: 25; Doudna & Charpentier, 2014: 1077).

In the era of genetic engineering, a new genome editing technology CRISPR-Cas9 has proved to be an advancement for both the scientific community and public for its potential to alleviate several genetic diseases. CRISPR is an acronym for Clustered Regularly Interspaced Short Palindromic Repeats, a part of the bacterial defence system which serves as the foundation of the genetic engineering technology. When the bacteria are invaded by a virus that previously infected it, it utilises an enzyme termed as, CRISPR-associated protein or Cas, to locate and cut the virus' DNA. Scientists adapted this bacterial self-defence mechanism for precise and targeted manipulations of DNA sequences in any organism (Doudna & Charpentier, 2014).

However, from a bioethical perspective, there are numerous questions regarding the potential limitations and dangers of this technology. There is substantial coverage of CRISPR-Cas9 in the news media as it is associated with both scientific revolution and bioethical controversy, which makes it particularly newsworthy. Although bioethicists have widespread opinions, one of the key arguments is about the ethical use of the technology in the human germline alterations which may lead to unforeseen consequences for future generations (Cribbs & Perera, 2017: 626).

In April 2015, a paper published by a Chinese group sparked controversy about the application of the technology to human embryos since off-target effects were observed in their experiments on pre-implantation embryos (Liang, Xu, Zhang, Ding, Huang, Zhang, Lv & Xie, 2015). In late November 2018, bioethicists, scientists and the media reacted with shock when He Jiankui, an associate professor at the Southern University of Science and Technology in Shenzhen, China, announced via YouTube that he had genetically altered human embryos using the CRISPR-Cas9 system, two of which were born out of an in vitro fertilisation (IVF) pregnancy (Krimsky, 2019: 19). The procedures and protocols followed by

He in his clinical trials, violated various ethical standards, including national regulations, global consensus guidelines and established laws of bioethics (Krimsky, 2019: 20).

The examples mentioned above establish that genes have become an increasingly influential role player in the public domain, as the field of genetics has moved from academic journals to mass culture, and from laboratory bench to the mass media (Takahashi & Tandoc, 2016: 681). News media coverage is one of the principal ways by which the public understands health and science, including emerging biotechnologies such as CRISPR-Cas9 (Marcon, Master, Ravitsky & Caulfield, 2019: 2).

Media coverage on CRISPR-Cas9 related incidents included not only positive expectations of curing diseases but also negative scenarios of a world of designer babies and Frankenscience (Baumann, 2016: 141). Therefore, the media play a vital role in steering the attention of the public to science and bioethical issues. The coverage of genetics is particularly newsworthy as it is often associated with controversy. Reports about genetic manipulation often reflect serious bioethical issues and thus influence the public's perception of genetic discoveries such as CRISPR-Cas9 and might also shape subsequent ethical policies and regulations (Nisbet, Brossard & Kroepsch, 2003: 38). Thus, the topic of genetic engineering remains infused with political, cultural and social tension (Nelkin & Lindee, 2004: 204).

Several challenges exist surrounding genetics reporting, such as poor public comprehension of genetics and negative associations with genetics such as eugenics. Historically, social engineering and genetics have had a controversial affiliation, with the most noteworthy example the unethical misuse of science in Nazi Germany to promote eugenic policies of ethnic cleansing and mass-sterilisation (Cribbs & Perera, 2017: 628). Thus, the bioethical concerns are not only for the protection of impending generations but also in what manner this technological system can transform society in terms of morality, social values and ethics.

The CRISPR-Cas9 system is also relevant in the South African context because the South African population encompasses unique genetic variations and mutations associated with disease (Naidoo, Fok & Scholefield, 2019: 56). Regardless of progress in traditional gene therapy, South African genetic research mostly contributed to diagnostic rather than therapeutic interventions because of financial barriers. The cost-effective CRISPR-Cas9 gene-editing system could be a useful tool for screening new drugs specific to South African

population diversity and implemented in therapeutic strategies (Naidoo, Fok & Scholefield, 2019: 57).

The Virodene case of 1997 in South Africa illustrates how the news media can influence the public perception of scientific topics (Malan, 2006: 41). The South African cabinet announced that the Virodene drug, discovered by researchers at the University of Pretoria, could be a possible cure for acquired immunodeficiency syndrome (AIDS). After this announcement, the South African newspapers reported on the cure but did not make the distinction that it was not yet peer-reviewed or ethically approved by the Medicines Control Council or the Research Protocol Committee. Such misrepresentation in news reports can have a significant impact on the public understanding of AIDS.

Over the last two decades, biomedical research in South Africa have been tightly controlled by ethical rules and regulations and research cannot start before it has not been reviewed and approved by research ethics committees (Silaigwana & Wassenaar, 2019: 108). On an international level, South Africa also plays an integral part in establishing bioethics regulations. In 2015, Stellenbosch University's Centre for Medical Ethics and Law became the first bioethics centre in Africa to collaborate with the World Health Organisation (WHO) (Bateman, 2015: 430). Currently, one of WHO's co-chairs for the Advisory Board for Gene Editing is Edwin Cameron, retired Justice of South Africa's Constitutional Court. University of Cape Town Bioethics Professor, Janita de Vries, is also a member of the expert panel which aims to develop frameworks and regulations for genetic engineering techniques such as CRISPR-Cas9 (Reardon, 2019: 444). South Africans therefore have a presence in the global bioethics arena where critical policy decisions are made with regards to genetics research.

1.2 Purpose of study

The academic visibility of scientists within their field of research depends on their scholarly publication and citation metrics. However, public visibility of scientists and scientific information rely on media exposure (Joubert & Guenther, 2017: 1). Science news does not have the same status as other beats such as politics, sport and business in South Africa (Claassen, 2011: 352). A study conducted by Van Rooyen (2004) found that less than 2% of editorial space is awarded to science-related topics in top South African news publications. However, the study suggested that biomedicine was covered most because of its

newsworthiness in terms of human health impact, novelty and controversy (Van Rooyen, 2004: 22). The applications of CRISPR-Cas9 technology are significant to the field of biomedicine and was chosen as a topic for this study due to its controversy and visibility in the media. Framing of scientific topics such as CRISPR-Cas9 plays an important role in how the public understands it and forms expectations surrounding it (Nisbet *et al.*, 2003: 38). According to Claassen (2011: 361), journalists and scientists agreed that the South African public often believes in miracle cures read in the news. Nelkin (2001:558) suggests that genetics as a topic attracts expectations of controlling disease which are often far-reaching. Therefore, the oversimplification or misrepresentation of scientific topics such as CRISPR-Cas9 in the media may create false expectations towards the potential of technology in its current state. For medical topics, a well-accepted guideline for good journalistic practice is to avoid sensational representations and if research results are still incomplete, then it should be represented as such. Thus, it is vital that the news media should only report accurate, truthful, objective and relevant news (McQuail, 2010: 76). Therefore, the researcher was interested in investigating how selected South African news media framed the bioethical and scientific topic of CRISPR-Cas9 in terms of scientific accuracy and ethical controversies and which expectations they set out in their reporting.

1.3 Problem statement

The scientific and bioethical implications of CRISPR-Cas9 is a topic of global importance and rapidly moved from the academic literature to the mass media. Reporting on scientific topics in the media such as genetic engineering often includes elements of sensationalism, pseudoscience and exaggerations. Therefore, researchers worldwide call for more evidence-based journalism in the field of science. This study will address how the media frame the topic and how it can influence the perception thereof. This research is important because to this researcher's knowledge a similar study has not been done in the South African context at the time of writing. The research might prove valuable for media practitioners, editors and for academic understanding of how South Africa framed the topic of CRISPR-Cas9 in the time period of the study. The findings will arguably shed light on the role of the news media in bioethical debates within context of a topic of global bioethical and scientific importance. This study seeks to analyse content about the bioethics of CRISPR-Cas9 in the South African media by looking at how reporters frame it. Data will be gathered through qualitative and quantitative content analysis of articles from the top 10 most popular South African news

media sites from January 2013 to June 2019. To analyse the articles obtained from news media, purposive sampling was used. The news media websites were chosen according to the top 10 most popular news media sites ranked by browsers on both computer and mobile devices in South Africa established by *Effective Measure* in 2018 (news24.com, timeslive.co.za, iol.co.za, ewn.co.za, enca.co.za, sowetanlive.co.za, thesouthafrican.com, huffingtonpost.co.za, Netwerk24, citizen.co.za).

1.4 Research questions

In order to address the problem statement, set out in section 1.3, the following general and specific research questions will be answered:

1.4.1 General research question

How did the South African online news media cover a new gene-editing technology such as CRISPR-Cas9 (from 2013 to 2019)?

1.4.2 Specific research question

Which frames did the SA media use when reporting on a gene-editing technology such as CRISPR-Cas9?

1.5 Brief chapter overview

This study is structured into 6 chapters.

In Chapter 1, Introduction, the researcher explains the rationale behind the study, highlighting the importance of bioethics in genetic engineering systems such as CRISPR-Cas9. Bioethical controversy is also particularly newsworthy and, therefore, highly publicised in the media. The media play an essential role in steering attention to such scientific matters and, in turn, can shape attitudes, behaviours and policies around bioethics.

In Chapter 2, Literature review, the researcher explains the science of CRISPR-Cas9 and the applications of the genetic engineering technology with examples of its successes and failures in scientific research. Then the review focuses on the history of bioethics and how this field of study originated out of several bioethical misconducts. The role of bioethics in the public domain is also explained, and the bioethics of CRISPR-Cas9 is described in full. Lastly, the importance of the role of the media in science, scientific and genetic reporting is highlighted along with its challenges.

In Chapter 3, Theoretical points of departure, the theory of framing embedded in social constructionism is summarised. Framing will serve as the theoretical background of this study. Several definitions of framing theory and framing processes will be explored.

In Chapter 4, Methodology, the general and specific research questions are stated as well as the research design and method. The advantages and disadvantages of using a qualitative and quantitative research design are discussed as well as the benefits and limitations of the textual content analysis method. The process of coding, as well as the quantitative method for data analysis, is explained.

In Chapter 5, Findings and analysis, the coding process is further discussed and illustrated. Quantitative findings are displayed in graphs and described, followed by a discussion of qualitative findings. Each subsection is based on specific research questions and aims to establish answers from the content analysis of the reports.

In Chapter 6, Conclusion, the most important findings are discussed and concluding remarks are made on how the study extended and problematised the knowledge of the field of bioethics reporting. The limitations of the study according to time, place and conditions are stated. Finally, recommendations for future research are made to encourage further inquiry into this topic.

Chapter 2: Literature review

2.1 Introduction

In this chapter, the science of CRISPR-Cas9 is explained from a genetic perspective, and subsequent applications of the gene-editing system, as found in the literature are explored, highlighting successful and unsuccessful scientific outcomes. Once the scientific background is established, the researcher reviews the field of bioethics in terms of history, public domain and the specific bioethics associated with CRISPR-Cas9. Lastly, the role of the media in reporting on science, genetics and bioethics is highlighted along with its challenges.

2.2 CRISPR-Cas9: The science explained

Since the discovery of the structure of DNA, technologies for modifying it have enabled great advances made in genetics research. However, establishing site-specific alterations in the genomes of living cells remained a challenge. Subsequently, there was a shortfall of suitable tools for precise and effective genomic editing (Doudna & Charpentier, 2014: 1077). However, since the discovery of CRISPR-Cas9 technology, the current generation of genome editing technologies have experienced rapid development (Hsu, Lander & Zhang, 2014: 1262).

The term CRISPR can be explained by understanding every part of the acronym. Starting with the Short Palindromic Repeats section, the Repeats consist of short pieces of DNA (20-40 base-pairs in length) organised in a palindromic manner (Figure 1). The reason for this palindromic organisation is that when the DNA is transcribed into RNA, they form hairpin turns (Yamamoto, 2015: 26).

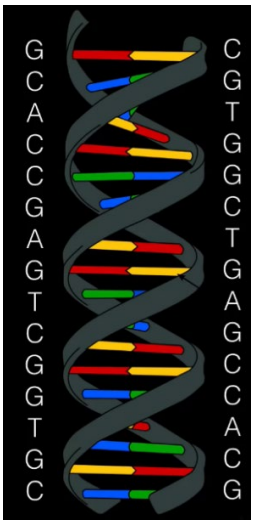

Figure 1. CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) (Source: Doudna & Charpentier, 2014).

Between these Short Palindromic Repeats, the DNA is Interspaced by spacer DNA that is not repeated. Interestingly, the spacer DNA matches up with viral DNA/bacteriophage DNA (Doudna & Sontheimer, 2014: 162). Along with this, scientists also identified *Cas* genes that produce two types of *Cas* proteins: helicases that unwind DNA and endonucleases that cut DNA (Haft, Selengut, Mongodin & Nelson, 2005: 62) (Figure 2).

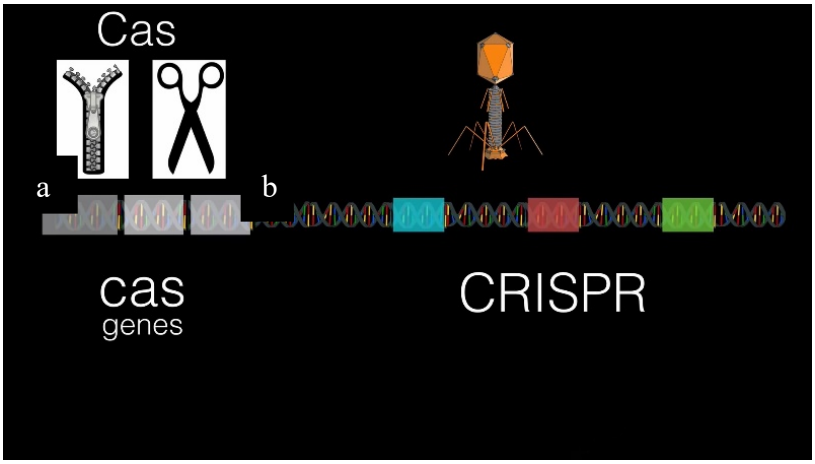

Figure 2. *Cas* genes producing two *Cas* proteins: a) helicases and b) endonucleases. Spacer DNA indicated in blue, red and green corresponding to the DNA of the bacteriophage (Source: Doudna & Charpentier, 2014).

Therefore, the CRISPR method was founded upon a natural defence system found in bacteria for immunity against viruses (Barrangou & Marraffini, 2014: 235). When bacteria recognise the invasion of virus DNA, it translates protein into a Cas-complex and transcribes DNA to make CRISPR-RNA (cRNA) which comprises a sequence that matches up with that of the intruding virus (Figure 3) (Wyman, Changeux, Filmer, Jovin, Baehr, Holbrook, Dattagupta, Crothers, Hatfield, Bruinsma, Maniatis, Harrison, Spakowitz, Blainey, Schroeder, Xie, Strzelecka, Dorner, Schildkraut, Aggarwal, Bailey, Steitz, Finzi, Bustamante, Martin, Patel, Kumar, Patel, Oehler, Aggarwal, Stayrook, Rosenberg, Lewis, Widom, Hynes, Szabo & Bustamante, 2013: 823).

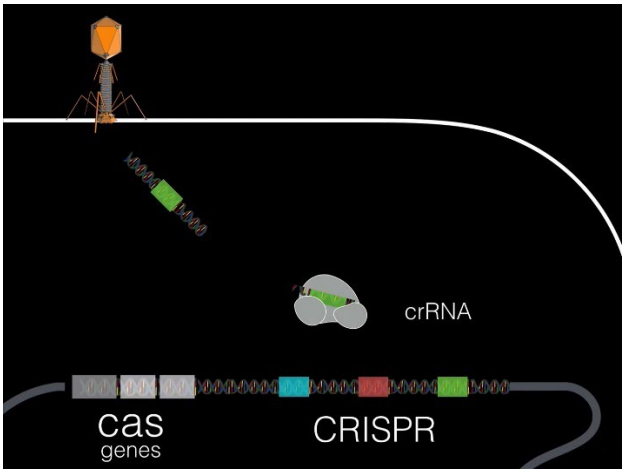

Figure 3. Cas-complex with cRNA matching the invading virus (Source: Doudna & Charpentier, 2014).

However, when the bacteria do not have a spacer that matches the viral DNA, it creates a different Cas-protein that breaks the viral DNA and most importantly copies the viral DNA into the CRISPR genome (Yamamoto, 2015: 27). Therefore, spacer-DNA can be viewed as a history of old viral infections.

Doudna & Charpentier (2014) studied the CRISPR-system of *Streptococcus pyogenes* that contains the Cas9 protein. The major structure of Cas9 is divided into two parts: firstly, nucleases that can cut DNA and secondly, two RNAs: cRNA and trans-activating crRNA (tracrRNA). The crRNA hybridises with the tracrRNA to form a crRNA:tracrRNA duplex (Figure 4) (Zhang, Shehata, Konermann, Hsu, Dohmae, Ishitani, Ran, Nishimasu & Nureki, 2014: 935). Doudna & Charpentier (2014) then discovered that they could modify and program the system by making a synthetic fusion of crRNA and tracrRNA into a chimaera termed guide-RNA (gRNA) that can cleave virtually any sequence in living cells (Zhang *et al.*, 2014:936) (Figure 4). This fusion gave rise to a two-part system: CRISPR-Cas9.

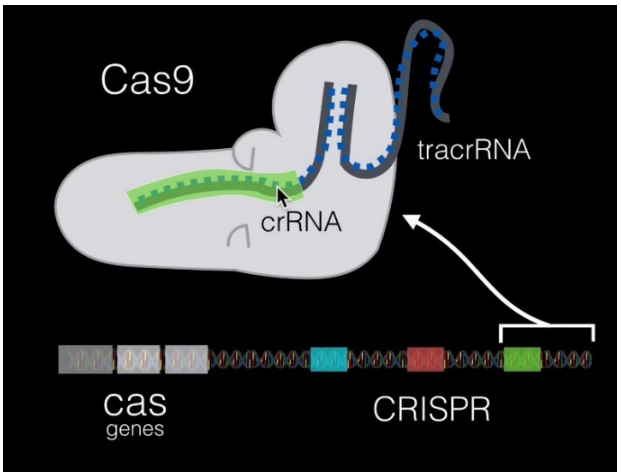

Figure 4. CRISPR-Cas9 system: cRNA and tracrRNA duplex (Source: Doudna & Charpentier, 2014).

This system works to disable the virus by cutting the viral DNA. Thus, the virus is disabled when the gRNA targets the viral genome and the Cas9 cut the target DNA (Wyman *et al.*, 2013: 822). The DNA will subsequently feed into the Cas-complex and undergo a double-stranded break when the corresponding sequence appears (Figure 5). When a double-stranded break occurs, certain repair mechanisms follow such as insertions or deletions to mend the break (Figure 5) (Hsu *et al.*, 2014: 1263).

Instead of the natural repair mechanisms, Doudna and Charpentier (2014: 1077) found that CRISPR-Cas9 could also be programmable and used as a technology. It can be programmed by adding synthetic host RNA when a double-stranded break occurs. Therefore, the CRISPR-Cas9 technology originates from the fact that the system cuts not only viral DNA but any DNA sequence at a targeted site by modifying the gRNA to correspond to the target. The replacement of mutant genes with a correct copy can be achieved by the addition of another section of DNA that contains the required sequence (Doudna & Charpentier, 2014: 1082). After the CRISPR-Cas9 system has made the cut, the required DNA sequence can pair up with the cut ends by recombination and subsequent replacement of the initial sequence with the new correct version (Figure 5) (Fogleman, Santana, Bishop, Miller & Capco, 2016: 41).

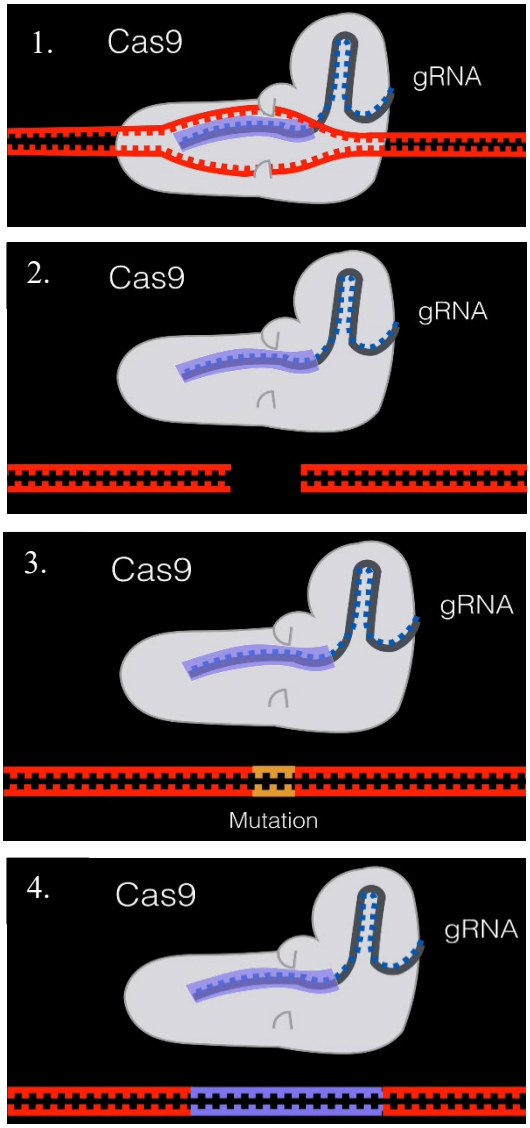

Figure 5. CRISPR-Cas9 system: The process of DNA cutting, double-stranded break with possible mutation or insertion of a new gene sequence (Source: Doudna & Charpentier, 2014).

The straightforwardness of the CRISPR-Cas9 system, together with the unique DNA cutting system and the capability for multiplex targeting of genes have facilitated significant developments in the field of genome editing. In essence, it is a relatively cost-efficient and accessible technology that can accurately target, edit and alter genomic loci (fixed position on a chromosome) of a variety of living cells and organisms (Doudna & Charpentier, 2014: 1077).

2.3 Applications of CRISPR-Cas9

The discovery of CRISPR-Cas9 gene-editing technology has revolutionized the field of genetics. Worldwide, laboratories are using the technology to pioneer new clinical applications in the field of biomedicine. In its current state, the technology can aid in basic genetic research by systematically analysing gene functions in cells. It can also monitor genomic reorganisations and the development of cancers or other illnesses, and possibly amend genetic mutations responsible for hereditary diseases (Doudna & Charpentier, 2014: 1079). Its application in genome-wide studies also permits extensive screening for drug targets. Furthermore, it can assist in the progress of genetically edited animal models that will advance pharmacological studies and knowledge of diseases (Doudna & Charpentier, 2014: 1081). However, the development of precise protocols for safe and efficient delivery of Cas9 and its guide RNAs to cells and tissues are still necessary before the application of the technology can be implemented in human gene therapy (Doudna & Charpentier, 2014: 1083).

The CRISPR-Cas9 system has already triggered innovative applications in biology. Firstly, it has led to the generation of genetically modified animal models of human disease. For example, when adult mice were injected with the system, necessary editing was accomplished in the liver to alleviate tyrosinemia (Yin, Xue, Chen, Bogorad, Benedetti, Grompe, Koteliansky, Sharp, Jacks & Anderson, 2014: 554). Tyrosinemia is a genetic disease characterised by disturbances in the metabolic series of actions that degrades the amino acid tyrosine, a building block of most proteins. If left untreated, tyrosine and its by-products accumulate in tissues and organs, which can result in life-threatening health problems such as liver and kidney failure (Charbonneau & Healy, 2005: 61). The CRISPR-Cas9 gene-editing system has also been applied to a canine model of Duchenne muscular dystrophy (DMD) and restored dystrophin expression to 90% of the normal levels in some dogs. Dystrophin is an important protein that functions to maintain muscle function and structural integrity, and these findings could be promising for the treatment of DMD (Amoasii, Hildyard, Li, Sanchez-Ortiz, Mireault, Caballero, Harron, Stathopoulou, Massey, Shelton & Bassel-Duby, 2018: 1).

Secondly, CRISPR-Cas9 applications seen in human cell culture studies are the inactivation of hepatitis B virus replication and of human immunodeficiency virus 1 (HIV-1) replication (Barrangou & Horvath, 2017:175; Liao, Gu, Diaz, Marlett, Takahashi, Li, Suzuki, Xu,

Hishida, Chang, Esteban, Young & Belmonte, 2015: 141; Dong, Qu, Wang, Wei, Dong & Xiong, 2015: 111). CRISPR-Cas9 has shown that introduction of Indels (insertion or deletion of bases in the genome) into HIV is lethal to the virus, however, it has also been shown that certain modifications to the virus lead to increased virulence (Wang, Pan, Gendron, Zhu, Guo, Cen, Wainberg & Liang, 2016: 483). Similar strategies have been used for the treatment of leukaemia and other blood cancers (Cox, Platt & Zhang, 2015: 126). These cell-based therapies have shown significant advantages because cells can be removed, manipulated, expanded, and then reintroduced into the patient to enhance the desired therapeutic effect.

Thirdly, gene editing in specific tissues such as the liver, heart and brain have been applied to disease models (Barrangou & Horvath, 2017: 171). However, for several diseases such as solid tumour cancers or those that affect tissues or organs, CRISPR-Cas9 is unlikely to be effective given the present state of the technology. Despite these setbacks, there are currently active areas of research that are pursuing the application of CRISPR-Cas9 into editing the cystic fibrosis transmembrane conductance regulator gene (*CFTR)* in cystic fibrosis (Schwank, Koo, Sasselli, Dekkers, Heo, Demircan, Sasaki, Boymans, Cuppen, Van Der Ent, Nieuwenhuis, Beekman & Clevers, 2013: 657). Recently, a study also showed promise in the amendment of muscular dystrophy in a human-engineered heart by using the CRISPR-Cas9 method (Long, Li, Tiburcy, Rodriguez-caycedo, Kyrychenko, Zhou, Zhang, Min, Shelton, Mammen, Liaw, Zimmermann, Bassel-duby, Schneider & Olson, 2018: 8). The system was also introduced into the mammalian nervous system for improvement of neuro-research disease models (Mei, Wang, Chen, Sun & Ju, 2016: 71).

Lastly, CRISPR-Cas9 has also been applied in the controversial field of germline editing. In 2015, Liang *et al.* became the first to edit genes in non-viable human embryos and found that only some cells were effectively edited, while the others stayed in wild type form (Li, Kang, Pang, Soh, Yu & Fan, 2018: 4; Liang *et al.*, 2015: 364). A research team at the Oregon Health and Sciences University in Portland also corrected a heterozygous mutation involved in a heart defect in a human embryo (Ma, Marti-Gutierrez, Park, Wu, Lee, Suzuki, Koski, Ji, Hayama, Ahmed, Darby, Van Dyken, Li, Kang, Park, Kim, Kim, Gong, Gu, Xu, Battaglia, Krieg, Lee, Wu, Wolf, Heitner, Belmonte, Amato, Kim, Kaul & Mitalipov, 2017: 419). The embryos used in these studies were not injected after gene editing as per bioethical regulations.

However, in 2018, bioethical guidelines for germline editing were breached. He Jiankui, together with his team of researchers, modified the gene that encodes the C-C chemokine receptor type 5 (*CCR5)* in human embryos (Krimsky, 2019: 19). They implanted these embryos, and they were carried to term, resulting in the first two CRISPR-Cas9-edited babies born in November 2018 (Cyranoski, 2019: 441). The specific genetic modification was selected to possibly provide HIV resistance (Marx, 2019: 147).

Despite these advancements, the CRISPR-Cas9 technology is currently in its infancy and is faced with challenges related to abovementioned delivery methods, off-target effects and unethical experiments.

2.4 History of Bioethics

The editor of the *Encyclopaedia of Bioethics*,Warren Reich, defines bioethics as the study of the dimension of ethics in biology and medicine (Reich, 1978). Bioethics as a field and discourse is comparatively new and emerged in the 1960s, but its origins can be found in traditional ethics associated with the Hippocratic tradition (Jonsen, 1993: 3).
Eugenics had a considerable impact on the course of bioethics. Francis Galton coined the term eugenics in the 1880s as a so-called scientific idea with the purpose of advancing racial quality through forced abortions, compulsory sterilisations and mass murder of races deemed inferior (Galton, 1875).

The field of bioethics has gradually evolved in the last century because of several cases of bioethical misconduct. Some of the atrocities in medical research include the Tuskegee Syphilis study in 1932. In this study, 400 black men were infected with Syphilis and studied without being informed or treated for the infection even after penicillin was deemed as an effective antibiotic treatment for Syphilis (Ogungbure, 2011: 78).

One of the first international bioethical codes, the Nuremberg Code, was established as a result of 23 medical professionals from Nazi Germany that went to trial for ethical misconduct (Artal & Rubenfeld, 2017:109; Shuster, 1997: 1437). Paradoxically, it was suggested that the Nuremberg Code was based on the German Guidelines for Human Experimentation, formerly written in 1931 but withheld and never implemented to support the eugenics movement (Ghooi, 2011: 73). Nazi medical research exposed patients to racial sterilisation, hypothermia, decompression (high altitude), pathogens, starvation, and traumatic injuries (Weindling, 2014).

In 1948, following the Nazi Doctors' Trial, several ethical codes emerged such as the Helsinki Declaration on Ethical Principles for Medical Research involving Human Subjects issued by the World Medical Association (WMA) in 1964 (World Medical Association, 2014: 14). In 1979, the Department of Health Education and Welfare issued the Belmont Report (Department of Health, 2014). Beauchamp and Childress (1994) established The Four Principles of Biomedical Ethics, including autonomy, nonmaleficence, beneficence and justice. In 2002, the Council for International Organizations of Medical Sciences (CIOMS) implemented the International Ethical Guidelines for Biomedical Research (Council for International Organizations of Medical Sciences, 2002). In 2005, the United Nations' Educational, Scientific and Cultural Organisation's (UNESCO's) Universal Declaration on Bioethics and Human Rights was declared and is widely used and applicable to developing countries such as South Africa (UNESCO, 2005).

The development of bioethics is consequently connected to the history of poor implementation of ethical regulations in the medical community and the necessity to develop external regulatory frameworks to ensure it. The field of bioethics today requires compliance with ethical codes in biological research and practice. Today, the primary focus is on minimising risks and ensuring the safety of human participants in studies and their voluntary involvement. Presently, ethical conditions, regulations, and procedures are embedded in laws and policies implemented by national and international organisations supervised by independent Research Ethics Committees or Institutional Review Boards (Artal & Rubenfeld, 2017: 113).

2.5 Bioethics in the public domain

Ever since the 1970s bioethical thinking began to integrate into the social world, with social scientists, philosophers, and most recently, cultural and media theorists joining the conversation (Zylinska, 2009: 20). Therefore, bioethics is not only confined to the clinic but is also present in the broad social dimension. For example, in the 1970s, biomedical issues entered the public domain as groups argued over abortion and the use of foetal tissue for experimentation (Reich, 1995: 25). The media reported on these biomedical debates which, in turn, influenced state policymakers.

It can be suggested that the increased focus on bioethical topics outside the clinic and scientific community is because general well-being and health are recognised as a moral concern (Zylinska, 2009: 21). Certainly, moral concerns are one of the central ways through

which bioethical concerns are introduced in the public sphere. This is only intensified by the media (television, Internet, newspapers and radio) where the moral issues regarding, for instance, the triple measles, mumps, and rubella vaccination, genetically modified foods or cloning are often presented in a moralist context, as opposed to the context of scientific advancement, to make it more collectively binding. Besides scientists, journalists and the general public also make constructive contributions to the narrative on bioethics. Therefore, it is suggested that bioethics also has a functional role as part of public discourse that develops out of the concerns of society, as it does out of the knowledge of the academics. This idea stems from the theory of the public sphere developed by Jürgen Habermas (1989), a concept which depicts a space for rational communication and public debate. Habermas emphasised the importance of news agencies in the public sphere to help people understand society and, through reasonable discussion founded on that information, make educated choices about the world (Habermas, 1989: 27). Thus, it can be suggested that the vitality of the public discourse about bioethics ensures that it remains a significant and important topic of discussion.

As Jonsen (1993: 4) suggests, public involvement provides a platform for the field of bioethics. Divergent views and standards present in public discourse inform individual and social judgement about new developments in science and technology and ultimately informs bioethics (Jonsen, 1993: 5). Miah (2005: 410) also argues that the involvement of the public in the bioethical debate can have a constructive effect as it assists the progression of public awareness and understanding of science. Participation in a discourse on bioethics can take the debate beyond the moral aspect of it and reposition both science and bioethics as participative practices that influence and are influenced by the public (Zylinska, 2009: 22).

2.6 Bioethics of CRISPR-Cas9

The age of genome engineering gives rise to various ethical questions that should be discussed by scientists and society at length. The main question is how to maximise benefit while minimising risk in using such a powerful genetic tool. The role of scientists, science communicators and the media in creating a fair and balanced picture of genome engineering and the expectations it entails, is also relevant here. Regulatory agencies also have the responsibility to decide how they can control the use of CRISPR-Cas9 technology without limiting research and development (Doudna & Charpentier, 2014: 1083).

The CRISPR-Cas9 system raises significant questions about the suitable use of the system. Ethical considerations span from clinical, environmental and agricultural issues, but most interest is placed on human-germline editing. In the field of genetics, it is argued that human-germline editing has the potential to eliminate genetic diseases and, eventually, change the course of evolution. This potential change in evolution is due to CRISPR-Cas9's functionality in both somatic (non-reproductive) cells and germ (reproductive) cells (Liang *et al*., 2015: 363). In somatic cells, genomic changes are not heritable, but if the genomic editing is done in germ cells, that develop into sperm or egg cells, the changes are heritable.

Amongst the immense range of potential genetic modifications, it is valuable to differentiate between genetic correction and genetic enhancement. Genetic correction involves editing a unique mutation that has a high possibility of initiating a severe genetic disorder, with the objective of transforming the mutation into the DNA sequence carried by healthy individuals. In contrast, genetic enhancement incorporates much more extensive efforts to enhance humans in the development of so-called designer babies. The biggest concern in this context is that if CRISPR-Cas9 is used to edit genes for genetic enhancement, the groups that cannot afford the technology could be stigmatised (Fogleman *et al.*, 2016: 49). Genetic correction is widely believed to be permissible, but genetic enhancement is not (Vaughn, 2015: 222).

Lowering disease risk by substituting genes with alternate ones also faces several challenges because variants that reduce the risk of some ailments increase the risk of others. For instance, a general variant of the *SLC39A8* gene reduces the risk of developing Parkinson's disease and hypertension but raises the risk of developing Crohn's disease, schizophrenia and obesity (Costas, 2018: 275).

Thus, opinions on human-germline editing differ extensively. A few encourage the swift development of the technology, whereas others recommend prohibiting it. Currently, 30 countries have laws that directly or indirectly restrict all clinical uses of germline editing (Araki & Ishii, 2014: 108). The South African National Health Act (2004) prohibits genetic manipulation of the human germline. In some cases, the health minister may allow research on stem cells and zygotes not older than 14 days if the researcher underwent an appropriate application process, and informed consent is obtained by donors. However, some researchers breach these ethical regulations and spark debates on the effectiveness of such regulations.

One of the key papers that sparked the beginning of the embryo editing debate was published in *Protein & Cell* (Liang *et al*., 2015: 363). In the paper, they discussed how they utilised the CRISPR-Cas9 system to modify DNA in human embryos in an effort to repair it by adding new DNA (Liang *et al.*, 2015: 365). In order to get ethical approval, they used non-viable embryos from reproductive clinics. However, using this method in a clinical setting raised several obstacles.

The scientists injected 86 embryos with the CRISPR-Cas9 system, together with molecules designed to insert the new DNA. Only 28 embryos were effectively cut, and only 4 contained the new genetic material meant to repair the cuts (Liang *et al.*, 2015: 366). This occurred due to off-target mutations initiated by the CRISPR-Cas9 system functioning on other portions of the genome than the targeted site (Cyranoski & Reardon, 2015: 593). Therefore, the team concluded that the technology was still too immature to successfully edit the human genome. However, George Church, a Harvard geneticist, argues that the researchers did not use the latest CRISPR-Cas9 technology and their challenges could have been lessened or avoided if they did (Cyranoski & Reardon, 2015: 594).

Recently, He Jianku started with a project to genetically engineer human embryos with the objective of pregnancy and live birth. He recruited couples with an HIV-positive father for the experiments in March 2017. In early November 2018, the gene-engineered twin girls were born. On 25 November, the MIT Technology Review revealed the existence of the research and the Associated Press released the story to the public. On 28 November, at the gene-editing summit in Hong Kong, He was widely criticised for breaching international ethical regulations as well as national ethical guidelines in China for embryo research. Therefore, China's National Health Commission ordered an investigation into He's experiments, and He was subsequently censured by the health ministry of Guangdong and dismissed from the Southern University of Science and Technology in Shenzhen, China. He's work illustrates the double-edged sword of this technology. He's work aims to reduce the risk of the twins obtaining AIDS if subjected to HIV later in life by attempting to disable the *CCR5* gene, which encodes a receptor that HIV uses as an entry into cells. Nevertheless, this gene modification is not harmless: it has been found to increase the risk of complications by making carriers more susceptible to other viruses, such as influenza and West Nile virus (Carlin, Hemann, Zacharias, Heusel & Legge, 2018: 781).

He Jiankui violated ethics in several ways. Firstly, He has not published previous studies of CRISPR edits on animal embryos such as mice, primates or non-viable human embryos (Brokowski & Adli, 2019: 90). He also did not report risks of gene-editing embryos or how commonly seen off-target effects would be addressed. Further, no references are provided on He's website, video or public statements on how to minimise risks that would permit the gene-editing according to scientific consensus (Wang, Li, Li, Gao & Wei, 2018: 345). He also did not meet China's ethical guidelines for embryo research that prohibit the implantation of embryos used in research (Zhang & Lie, 2018: 25). He breached the Southern University of Science and Technology's ethical framework. He also recruited parents on the basis of undue inducements such as in vitro fertilisation (IVF) payments, daily allowances and supportive care amounting to approximately $40 000 (Schaefer, 2018). The high inducement could cloud the judgement of the parents, which prohibit them from making informed decisions weighing risks and benefits. Moreover, He's informed consent form was insufficient in explaining off-target effects with unwanted and unforeseen consequences. He also had conflicts of interest as he is a board member and investor in multiple companies in Guandong and Beijing and such involvement requires disclosure in the informed consent form (Coleman, 2018).

Based upon several public conversations such as the International Summit on Human Gene Editing in December 2015, and the WHO Expert Advisory Committee on Developing Global Standards for Governance and Oversight of Human Genome editing, guidelines were developed to regulate human gene-editing (WHO, 2019). The following ethical guidelines have been established (Doudna, 2015: 56).

- Safety: standard methodology needs to be used in order to measure genome-editing efficiency as well as off-target effects in order to establish clinical relevance.
- Communication: bioethics committees need to provide accurate information to the public about the social, ethical, scientific and legal consequences of genetic-editing.
- Guidelines: international standard guidelines need to be developed to illustrate what is ethical research and what is not. Fourth, regulation: evaluation of specificity and efficacy of research should be supervised.
- Caution: human genome modification should not proceed until the social consequences, and the safety of the technology have been established.

In March 2019, several specialists from seven countries called for a global moratorium on all clinical uses of human germline engineering to make genetically edited children. This entails the establishment of an international framework where governments publicly and voluntarily commit to disapprove clinical germline editing for a fixed duration (for example five years) until certain conditions are met (Lander, Baylis, Zhang, Charpentier & Berg, 2019: 165). These conditions include transparent evaluation of medical, technical, scientific, societal, ethical and moral concerns.

2.7 Science: The role of the media

The mass media are considered one of the most significant resources of scientific knowledge for laypersons after they complete their school education (Dunwoody, 2014: 33). Since most people do not have any direct contact with the scientific community, their only source of information about science, scientific processes and scientific findings are the mass media (Priest, 2013: 140). Over the last decade, several cross-country studies prove a continuous increase in media coverage of science, especially in the print media (Schäfer, 2010: 7; Elmer, 2008: 878; Bucchi & Mazzolini, 2003: 8). Therefore, the mass media are regarded as a principal sphere of influence within which scientific controversies and issues come to the awareness of interest groups, policymakers and the public (Geller, Bernhardt, Gardner & Rodgers, 2005: 198). Not only do the media influence science-related attention, attitudes and behaviour of the public, but they also form how policy issues associated with scientific debates are characterised, symbolised and ultimately solved (Nisbet *et al*., 2003: 38).

In 1985 the Royal Society's report on the *Public Understanding of Science* highlighted the importance of better communication between scientists and journalists. The report stated that scientists need to learn about the media and explain science without using jargon (Royal Society, 1985). Numerous studies highlight the importance of this relationship between science journalists and scientists to advance the public understanding of science (Takahashi & Tandoc, 2016; Dudo, 2015; Claassen, 2011; Bauer, 2000; Bucchi, 1996).

However, science journalists have been criticised in several aspects, ranging from being inaccurate, uncritical and failing to point out scientific uncertainty. Nelkin (1995: 32) argues that the media tend to focus on frontier science (often untested and unverified) and reduce complex research findings to misleading reports which are often exaggerated or incorrect and

later refuted by contradictory reports. Therefore, it is the media's responsibility to distinguish between frontier and textbook science (tested and verified).

Evaluations of scientific news reports find few explanations of the research methods employed. Several studies on this found that science reports did not contain methodology of the scientific process and therefore restricts in-depth discussions of process information (Hijmans, Pleljter & Wester, 2003; Koulaidis, Dimopoulos & Sklaveniti, 2002; Einsiedel, 1992). Reporting of science in the media often includes elements of sensationalism, pseudoscience, negativity in choice of science topic and reluctance to publish corrections (Fjæstad, 2007: 123). Therefore, researchers worldwide are calling for more evidence-based journalism (Dunwoody, 2014: 27).

On the contrary, a survey of more than 1300 researchers in Japan, Germany, France, United States, and United Kingdom revealed that 57% of the scientists had a mostly positive experience with the media, and only 6% were unhappy with the journalistic outcome (Peters, Brossard, Cheveigné, Dunwoody, Kallfass, Miller & Tsuchida, 2008: 204). The survey revealed that most of the scientists agreed that their work was portrayed accurately and that the journalists were informed, unbiased and responsible in their reporting. The most commonly cited motivation for scientists communicating with journalists was to increase the public's appreciation of science (Peters *et al.*, 2008: 205).

Several scientific issues are covered in the media, but substantial focus is placed on genetics, due to the noteworthy accomplishments associated with it, such as the Human Genome Project and bioethical controversies such as genetic modification and germline editing (Geller *et al.*, 2005: 199). Germline editing covers the basics of a successful journalistic story since it often involves novelty, strangeness, the question of immortality, curiosity about the unknown, hope in miracle cures, fascination and terror caused by possible subversion of the so-called natural order (Carra, 2007: 102).

A study conducted by Geller *et al*. (2005) examined the experience of scientists and science writers concerning genetic reportage. It was found that scientists and science writers agree that controversy, applicability, novelty, and entertainment value make genetic reporting newsworthy. By comparison, science writers assigned higher significance to novelty and entertainment value. When queried about their social responsibility scientists put emphasis on education, whereas science writers intend to notify the public about the limitations and risks of the genetic subject at hand (Geller *et al.*, 2005: 201).

The challenges associated with audience reactions on genetic reporting include poor public understanding of genetics and associations of genetics with eugenics. When journalists cover genetic topics, they are often selective, unbalanced or inaccurate in their reporting, and therefore it leads to a similar reaction from the audience (Geller *et al*., 2005: 199). However, the reaction of the audience can also be selective or inaccurate because of poor public understanding of genetics. Therefore, to bridge the communicative gap, science journalists should be specially educated and trained on the fundamentals of the technology before they can facilitate rational public discourse about topics such as CRISPR-Cas9 (Voigt, Marzinkowski, Guenther, Bischoff & Löwe, 2017: 42; Schünemann, 2013: 136; Claassen, 2011: 351; Geller *et al.*, 2005: 203).

2.8 Summary

In conclusion, expectations of CRISPR-Cas9 as a gene-editing system for designer babies are far beyond the current state of the technology. Regardless of the advancements, the technology is still in its early stages and faced with several technical and bioethical challenges. Therefore, views on the use of human-germline editing vary significantly. However, presently, there is a call for a global moratorium on the use of human germline editing. The mass media, as a crucial part of the public sphere, inform citizens of these scientific controversies. If science journalists rely on evidence-based information to base their reporting on, it can enhance public understanding of the technology and possibly shape regulatory policies related to the bioethics of CRISPR-Cas9. In the next chapter, the theory of framing further supports how the media can shape the reality of its audience.

Chapter 3: Theoretical points of departure

3.1 Introduction

Within mass communication theory, certain theoretical models exist to aid in the understanding of the behaviour of the media and its audience. In this study, we will be using framing theory which has its intellectual roots in social constructionism (McQuail, 2010: 111). The central idea of social constructionism is that society is a construct rather than a stationary reality. Social constructionism stems from meaning production theory, which in turn has its foundations in symbolic interactionism and phenomenology (McQuail, 2010: 111; Fourie, 2007: 146). From the work of Alfred Schultz, phenomenology assumes that reality is constructed by meaning that is established by humans, and the mass media play a significant role in the construction thereof (Fourie, 2007: 147). The main assumptions of symbolic interactionism are that the mass media are not merely conveyors of knowledge but rather active constructors of meaning, by placing either more or less emphasis on certain events (Fourie, 2007: 148). In this field, it is argued that the structures and notions of society are shaped, challenged and changed by humans (McQuail, 2010: 112). In other words, human beings are responsible for the construction of social reality.

These theories are relevant to mass communication as they are at the core of understanding how the media influence society. There is a consensus among media scholars that news can only provide a selective construct consisting of pieces of information bound by a certain frame, angle or news process. Therefore, the mass media construct a part of reality by which certain ideas, events and people are given value (McQuail, 2010: 113 From this, certain theories in the news media such as framing exist to describe the taken-for-granted processes behind the production of news Within the field of mass communication, framing can be delineated and operationalised based on social constructionism (Scheufele, 1999: 105). Mass media actively produce frames of reference in reports that readers use to understand and form discourses around events and topics (Tuchman, 1978). Simultaneously, people's information processing and interpretation are affected by prior meaning structures or schemas. Three dimensions of news processing have been identified (Kosicki & McLeod, 1990). Active processing refers to the process of investigating additional sources founded on the assumption that information distributed by the mass media is incomplete. Reflective readers think about information from the mass media or discuss it with others to comprehend what they have learned. Finally, selective readers use mass media only to obtain information

relevant to them. In summary, according to the social constructivist media effects model, readers depend on a version of reality based on personal experience, interaction with peers, and interpreted selections from the mass media (Neuman, Just & Crigler, 1992).

3.2 Framing

The mass media compose a part of reality by which certain occurrences, people and concepts are given meaning (McQuail, 2010: 113). People rely on the news media for information about subjects that they have restricted direct knowledge about but also to strengthen their understanding or interpretation thereof (Franklin, 2007: 85). The media deliver dynamic content for the construction of reality by selectively reproducing certain meanings. The principle of framing is that the media frame reality for their audience in a specific way in which the consequence is a media-constructed version of reality (Callaghan & Schnell, 2010: 184). Framing can be utilised as a tool to explain complex scientific concepts such as CRISPR-Cas9 and to make it more salient (McQuail, 2010: 113). However, framing can also lead to a media-constructed version of genetic engineering, with a subsequent impact on readers' perceptions of it. Once such a perception is formed, it can be difficult to change it (Geller, Bernhardt, Gardner & Rodgers, 2005: 204).

The seminal work of Goffman (1974) spearheaded the framing analysis theory. Goffman suggested that the way in which a message is organised influences succeeding thoughts and behaviours. He proposed that people organise and classify their life experience to understand it. These schemata of interpretation are termed frames and enable us to identify, perceive, locate and label life experiences.

The concept of a frame with regards to the news has been extensively used in place of terms such as a frame of reference, news angle, theme or context (McQuail, 2010: 480). The agenda-setting theory coined by McCombs & Shaw (1972) is also closely related to framing theory. Agenda-setting is known as the process by which more attention is given to certain subjects in the news, to encourage public awareness resulting in attribution of importance (McQuail, 2010: 481). Therefore, it is necessary to define the theory of framing with precision.

Gamson and Modigliani (1989: 33) defined a media frame as a central concept that gives meaning to a series of events and uncovers the essence of the issue. According to Entman (1993: 52), framing is implemented to select certain aspects of perceived reality to make them more noticeable, resulting in the promotion of a specific problem definition,

interpretation, moral evaluation or remedy. Framing occurs at four levels: in culture, in elites such as politicians, in communications texts; and in the minds of individuals (Entman, 1993). Numerous media tools can be applied to achieve these functions, for example, specific phrases or words, contextual references, typical examples and the use of film or pictures (McQuail, 2010: 395).

There is agreement among media academics that news can only offer a selective construct comprised of fragments of information bound by a certain angle, frame or news process. Concepts such as news values, gatekeeping, agenda-setting and framing are examples of such processes (McQuail, 2010: 308). The theory of framing proposes that the readers will be directed by the journalistic frames in what it learns (McQuail, 2010: 481). In framing theory, it should be taken into account that the way in which journalists frame the news, and how the audience frames news, may be the same or different (McQuail, 2010: 397). Therefore, it is not always evident how framing will operate as an effect process. For instance, what differentiates a framing message from a persuasive message? According to Entman, Matthes and Pellicano (2009: 177), a frame recurrently invokes similar objects and traits, using synonymous or identical words and symbols in a sequence of related communications concentrated in time.

The process of framing can be active or passive. D'Angelo (2002: 877) suggests that frames are intentionally pitched cues used as a psychological device to manipulate significance and influence judgement. In contrast, Koenig (2006: 63) suggests that frames are basic cognitive structures which occur naturally in the course of communication. In this case, frames of a certain story are formed unintentionally and can be used to identify social themes and cultural narratives.

We can also distinguish between generic and issue-specific frames. Generic frames do not have thematic constraints and can be identified across several issues and contexts (Entman *et al.*, 2009: 176). Semetko and Valkenburg (2000: 95) suggested five categories for generic frames: human interest, conflict, morality, accountability and economic effects. On the other hand, issue-specific frames are related to particular events or topics. CRISPR-Cas9 can be classified as an issue-specific frame from which the media creates expectations that the technology can for example cure several diseases.

Scheufele (1999: 114) established a model of framing effects that reflect on audiences, journalists and media organisations. The model suggests four interconnected framing

processes. The first process is the creation and use of media frames by reporters that add specific angles and news values to the articles. Secondly, these framed articles are transferred to the readers. Thirdly, the audience approves and implements specific frames which result in a shift in their perception, attitude or behaviour. Lastly, there is a connection between media frames and individual frames which may be similar or different (Scheufele, 1999: 115). Fairhurst and Sarr (1996: 577) suggested the following framing techniques: metaphors, stories, tradition (rituals and ceremonies), slogans and jargon, contrast and journalistic spin (to create inherent bias).

Frames used by journalist direct the audience to comprehend certain events in a specific way. Since these frames come from the journalist, complete objectivity is improbable (McQuail, 2010: 396). Notwithstanding these complexities, there is enough proof to substantiate the process of framing and its influence on the receiving audience (McQuail, 2010: 528).

The CRISPR-Cas9 system is one such topic where frames are employed by journalists to explain complex genetic concepts (McQuail, 2010: 481). With regard to CRISPR-Cas9, frames are often drawn from science fiction characters such as superheroes or monsters. These science-fiction frames are frequently applied to prompt fear and uncertainty by the use of myths such as Frankenstein to warn against germline editing being dangerous and violating the so-called natural order (Baumann, 2016: 153). The mechanism of the technology is also often framed as molecular scissors which cut DNA. These frames are utilised to delineate the complex technology but may oversimplify the science. The audience may fear misuse of the technology because it is framed in the media as easy to use which is an oversimplification of the technology. Thus, framing is more than an assistance to explanation, and recurring frames influence the manner in which the public construct their views about scientific issues (Nelkin, 2001: 556).

When the media frame an issue in a certain way early on in a debate, it can be difficult for policymakers to challenge that frame with a different perspective (Geller *et al.*, 2005: 204). In other words, while scientists or policymakers frame the technology as a scientific breakthrough which may aid in the curing of genetic diseases, it may be replaced by the media's frame of designer babies or Frankenstein myths. Although people interpret scientific information and add meaning to frames within the context of their personal lives and prior knowledge, frames are still powerful and influential tools.

3.3 Summary

Chapter three was aimed at providing a comprehensive theoretical framework for the study. Framing analysis theory was described, and different definitions of framing were explored. The power, influence and the role of the media and its audience were described in terms of this theory. Thereafter, we distinguished between active and passive frames as well as generic and issue-specific frames. Moreover, four framing processes and several framing techniques were discussed. In the next chapter, we will describe the research design and methodology of this study.

Chapter 4: Methodology

4.1 Introduction

In this chapter, the research design is described in detail. Sections include the research design, data gathering, sample, and method of data analysis. Advantages and disadvantages of the research methodology are also identified.

4.2 Research design

Situated in the field of journalism studies, this study will use a qualitative and quantitative research design. The mixed-methods approach exists to fully understand the nature of a research problem. The use of multiple methods is often referred to as triangulation and proves to be a valuable research strategy since each research method has its advantages and disadvantages (Babbie, 2010: 118). The use of triangulation in qualitative and quantitative methods can be beneficial since the latter approach lends breadth and representativeness, and the former detail and depth (Madianou, 2009).

Qualitative research is defined as a process of organising data into categories and identifying patterns from non-numerical data to construct an interpretation thereof by using methods such as interviews, ethnography and content analysis (Du Plooy, 2009: 30). Qualitative research further permits the researcher to observe data in a natural setting and increase the depth of understanding. The method is particularly flexible which allows it to be utilised in new areas of interest. Qualitative methods are considered as the most appropriate method to study, describe and understand social phenomena (Amadi, 2011: 81). However, it is also possible to lose objectivity in a qualitative approach (Wimmer & Dominick, 2011: 48).

Quantitative research is defined as the systematic investigation of observable phenomena via numerical techniques (Babbie, 2010: 25). Quantitative research necessitates the measurement of categories and allows for more precision in reporting results (Wimmer & Dominick, 2011: 49). Quantification allows for more explicit and objective observations and improves the accessibility of data comparison and summation. The method is direct and concrete because measurable variables are used. However, if using the numerical method alone, richness of meaning can be lost (Babbie, 2010: 26). Therefore, in this study, the method of textual content analysis will be used quantitatively and qualitatively.

Content analysis is defined as the study of documented human communications (Babbie, 2010: 332). It is categorised as unobtrusive research since it studies social behaviour without affecting it (Babbie, 2010: 295). Content analysis is particularly relevant to communication studies because it answers the standard question of communication studies as Babbie (2010) indicates: "Who says what, to whom, why, how, and with what effect?" The method is useful in investigating both evident and covert meanings and the understanding thereof (Lowrey & Shan, 2018: 137). The strengths of content analysis are in its cost-effectiveness, the ability to correct errors by re-coding or adjusting codes, and can also be implemented as a method in longitudinal studies (Babbie, 2010: 321).

Yet, content analysis is restricted in terms of only enabling the study of formerly documented data, and questions could be raised about the validity and reliability of subjective coding (Babbie, 2010: 344). Still, the method is especially suitable for journalism studies because it can determine a variety of techniques used by journalists and establish the scope and trends of various reporting techniques such as framing (Jacobson & Marino, 2016: 532). Thus, content analysis can be applied to determine how the press creates expectations surrounding controversial matters such as CRISPR-Cas9 (Di Salvo & Negro, 2016: 810).

Since this study refers to public information, ethical approval is not required.

4.3 Data gathering and sample

Data was gathered through quantitative and qualitative content analysis of articles containing the words "CRISPR-Cas9" or "CRISPR" from January 2013 to June 2019 that appeared on the top 10 most popular South African news media sites.

The selection of the study period was made since it covers an extensive period of study that permits a comprehensive overview of reporting on CRISPR-Cas9. The year 2013 was chosen as a starting point because CRISPR-Cas9 was used for the first time in human genome editing in January 2013 (Wyman *et al.*, 2013). The endpoint was chosen for the reason that a Chinese scientist, Jiankui, announced the first gene-edited babies at the end of 2018 and the researcher sought to investigate this violation of ethics as far as the study period allowed.

To analyse the articles retrieved from news media sites, purposive sampling was implemented. Purposive sampling is appropriate when studying specific characteristics and qualities of a topic (Wimmer & Dominick, 2011: 94). Babbie (2010: 193) argues that a

sample should be chosen based on knowledge of a population, its elements, and the purpose of the study.

Therefore, the news media websites were chosen according to the top 10 most popular news media sites ranked by browsers on both computer and mobile devices in South Africa established by *Effective Measure* in 2018 (news24.com, timeslive.co.za, iol.co.za, ewn.co.za, enca.co.za, sowetanlive.co.za, thesouthafrican.com, huffingtonpost.co.za, netwerk24.com, citizen.co.za). These news media sites were chosen because they include a broad range of media types, including newspapers, broadcasting, and electronic news across South Africa and internationally (Table 1).

Table 1. The top 10 news media sites defined according to media types.

1	*News24*	South African online news publication
2	*TimesLIVE*	South African online news publication
3	*Independent Online* (IOL)	South African news and information website
4	*Eyewitness News* (EWN)	South African multi-platform news publisher (radio, desktop, mobile)
5	*eNews Channel Africa* (enCA)	South African 24-hour television news broadcaster available online
6	*SowetanLIVE*	South African online news publication
7	*The South African*	South African online news publication
8	*Huffington Post*	International online news and opinion website
9	*Netwerk 24*	South African online news publication of Afrikaans newspapers: *Beeld*, *Die Burger*, *Volksblad* and *Rapport*
10	*The Citizen*	South African tabloid-style online news publication

Each news media site was used to retrieve as they feature an online search engine:

1. https://www.news24.com/
2. https://www.timeslive.co.za/
3. https://www.iol.co.za/
4. https://ewn.co.za/
5. https://www.enca.com/
6. https://www.sowetanlive.co.za/
7. https://www.thesouthafrican.com/
8. https://www.huffingtonpost.co.za/
9. https://www.netwerk24.com/
10. https://citizen.co.za/

The websites were accessed and searched for articles including the word "CRISPR" and "Cas9". One news media site, thesouthafrican.com did not have any articles on this topic, and this narrowed the sample down to nine news media sites adding up to a total of 111 different articles for analysis (Table 2).

Table 2. Number of CRISPR-Cas9 articles per news website with SowetanLIVE at a minimum of 5 articles and News24 at a maximum of 23 articles between 2013-2019.

SowetanLIVE	**5**
EWN	6
Citizen	8
HuffPost	9
IOL	12
eNCA	13
TimesLIVE	14
Netwerk24	21
News24	**23**

4.4 Method of data analysis

Content analysis utilises a process of coding which comprises of the conversion of raw data into a standardised form (Babbie, 2010: 338). Coding involves the active process of categorising data that belong to or represent some phenomenon. This process entails the assignment of labels or so-called codes to units of data, for instance, characters, keywords, or themes. Codes are defined as short phrases or words that capture the essence of visual or written data (Saldaña, 2013: 3). Comparable codes are then categorised and put into categories by means of continuous comparison (Babbie, 2010: 339). Coding can be accomplished by using manual approaches (paper and coloured pencils), computer-aided approaches with everyday software (Word, Excel) or specific data analysis software (NVivo) (Tracy, 2013: 186–187). In this study, computer-aided approaches with everyday software such as Microsoft Word and Microsoft Excel were used.

Coding can explore manifest or latent meanings of research material. Manifest coding involves counting of specific elements such as *in vivo* codes in order to determine meaning thereof. Manifest coding has the benefit of ease, reliability and specificity. Latent coding requires the researcher to view an entire unit of analysis (article) and make a subjective assessment. Latent coding is advantageous in exploring underlying meanings. In this study, the researcher will use both manifest and latent coding (Babbie, 2010: 301).

The coding process implemented in this study involves two cycles of coding (Tracy, 2013: 188). The first cycle, primary-cycle coding, also known as open coding, cuts the raw data down into smaller pieces. The second cycle, secondary-cycle coding, is used for categorising, integrating and conceptualising the data. Through these processes, patterns and trends contained in the data can be observed and established (Tracy, 2013: 189).

Primary-cycle coding involves the process of data immersion by reading and re-reading the entire scope of data and reflect on it by asking open-ended questions such as “what strikes you?” or “what is happening here?”(Creswell, 2007: 153). Answering these questions starts the process of coding. The articles from the news media websites were added to a Microsoft Word document to enable computer-aided coding. Primary-cycle coding starts with data immersion and then designating phrases or words that encapsulate their essence. Primary-cycle codes are generally also first-level codes. First level codes are descriptive and focus on basic processes and activities present in the data and do not require extensive interpretation

(Charmaz, 2011: 365). In this cycle, the researcher made use of *in vivo* codes that used the actual language and words present within the datum itself and used the Comment function found under the Review tab in Microsoft Word (Strauss, 1987: 64). The constant comparative method was also used for reviewing the data applicable to each code and re-coding them to avoid "definitional drift" (Gibbs, 2007: 6). This method proved to be circular, reflexive, and iterative.

Secondary-cycle coding necessitates critical analysis of codes identified in primary-cycle coding. These codes are analytic and interpretive or sometimes referred to as "focused" codes and provide explanations and theories (Saldaña, 2013: 213). From this, the researcher can identify patterns, guidelines and progressions. The process of coding can end if the researcher reached theoretical saturation (Glaser & Strauss, 1967: 212). Theoretical saturation is reached when no novel or relevant data arise according to a category, and the categories are well established and validated (Tracy, 2013: 195).

For the quantitative content analysis articles were categorised as scientific or ethical and classifications were derived for each category. In order to be categorised as a scientific article, it had to contain a description or definition of the CRISPR-Cas9 system/technology or research and application of the technology. To categorise the articles about ethics, the criteria was ethical regulations, risks, boundaries and debates relating to CRISPR-Cas9 technology. Based on the number of words relating to science or ethics, the articles were grouped into one of four categories: science, ethics, both or neutral in a Microsoft Excel spreadsheet (Table 3). To indicate whether the articles supported or criticised CRISPR-Cas9, the same principle was used, and articles were categorised into support, criticism, both or neutral in a Microsoft Excel spreadsheet (Table 4). A comparison was then drawn between the variables seen in Table 3 and 4. The number of articles relating to each category was counted using the COUNTIF function in Microsoft Excel. The values were then used as percentages in pie-charts.

Table 3. Number of articles relating to science, ethics, both or neutral.

Science	39
Ethics	27
Both	45
Neutral	0
	111

Table 4. Number of articles which displayed support, criticism, both or neutrality towards CRISPR-Cas9.

Support	36
Criticism	37
Both	36
Neutral	2
	111

Table 5. Comparison to establish whether articles supported or criticised articles relating to science or ethics.

Science + Support	29
Science + Criticism	1
Science + Both	8
Science + Neutral	1
Ethics + Support	1
Ethics + Criticism	22
Ethics + Both	4
Ethics + Neutral	0
Both + Support	6
Both + Criticism	14
Both + Both	24
Both + Neutral	1
	111

To investigate the role of framing the number of frames mentioned relating to science-fiction (*Frankenstein, monsters, Brave New World, Gattaca*), cutting (*scissors, trim, snip*) and programme functions (*Microsoft Word, find and replace*) were counted to evaluate the frequency of frames in CRISPR-Cas9 articles in a Microsoft Excel spreadsheet and expressed as percentages in a bar graph (Table 6).

Table 6. Number of times each frame was mentioned.

Science-fiction	24
Cut	52
Programme	18

4.5 Summary

This chapter explored the research design and methodology applied in this study – the differences between quantitative and qualitative methodologies were discussed with the strengths and limits of each and the advantages of using both methods in this study. Furthermore, the chapter investigates the reasons for selecting specific methods such as content analysis, the selection of media and the motivation behind the study period. Finally, the chapter elaborates on the process of coding both manifest and latent content as well as the two cycles of coding used in the qualitative content analysis. Lastly, the method of quantitative content analysis was explained. The next chapter will elaborate on the findings and analyse the results obtained from the research methodology described in this chapter.

Chapter 5: Findings and analysis

5.1 Introduction

This chapter gives an account of the findings from 111 CRISPR-Cas9 related articles analysed from nine South African news media websites. Firstly, the process of primary and secondary cycle coding is described and displayed in Table 6 and 7. Then the analysis section follows where quantitative findings are displayed in graphs, and qualitative findings follow.

5.2 Coding

Following the method of primary and secondary cycle coding for content analysis as described by Tracy (2013), articles were coded in Microsoft Word by using the Comment function found in the Review tab. In Table 6, examples of primary codes such as human, regulation and safety are represented by *in vivo* codes as found in the news articles. In Table 7, primary codes that relate to each other were then categorised as a theme to form secondary codes, for instance, bioethics (human + regulation + safety).

Table 6. Excerpt of primary coding.

Primary cycle coding	
Code	**Examples (*in vivo* codes)**
Fear	Moral panic, concern, terrifying, dangerous, shock, alarm, horrified, scary, dire, outcry, fears, anxiety, grave, risk, dreaded
Human	Embryos, moratorium on germline editing, somatic vs germline, designer babies, eugenics
Regulation	Regulatory barriers, safeguards, legal issues, ethical red lines, authorisation, legislature, tougher rules, violated laws, lax regulatory controls
Safety	Specificity, accuracy, efficiency, off-target, unintended, unpredictable, risks unknown

Support	Breakthrough, revolutionise, solution, fix, treatment, cure, stop world hunger
Criticism	Disapproval, condemnation, abominable, anger, unacceptable, irresponsible, outrage, backlash
Sci-fi	Monster, superheroes, superspecies, robots, robo sapiens, brave new world, Frankenstein, Frankenfood, enhanced humans, super-race, Gattaca
Cut	Scissors, trim, snip, gene surgery, scalpel-like, carnival claw
Programme	Cut and paste, find and replace, delete

Table 7. Excerpt of secondary cycle coding.

Secondary cycle coding	
Secondary code	**Examples (*in vivo* codes)**
Bioethics (Human + Regulation+ Safety)	Designer babies, regulatory controls, off-target
Negative (Fear + Criticism)	Scary, disapproval
Positive (Support)	Cure, solution
Frames (Sci-fi + Cut + Programme)	Frankenscience, molecular scissors, find and replace

5.3 Analysis

The quantitative findings are discussed, followed by the corresponding qualitative findings. The qualitative section follows a pattern in which the code is defined and its properties explicated. Examples are then provided from the articles to illustrate the code. Conditions under which it arises, changes or is maintained are described. If applicable, it is related to other codes.

5.3.1 Bioethics and science of CRISPR-Cas9 as represented in the South African news media

This section aims to answer if the South African news media focused on the bioethics or science of CRISPR-Cas9. The researcher categorised the articles into science-related, bioethics-related or science and bioethics-related (both) (Figure 6).

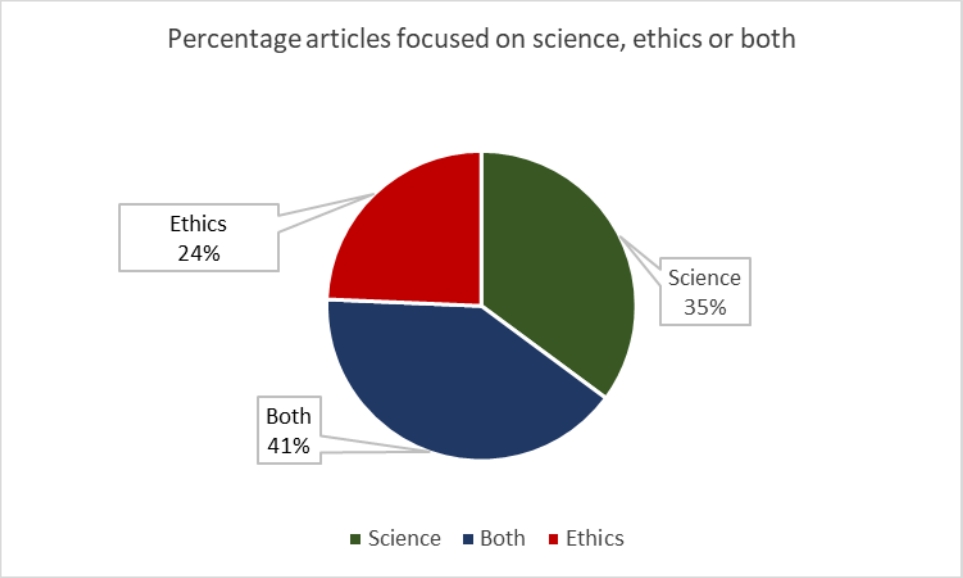

Figure 6. The percentage of articles focused on science, ethics or both.

In this pie-chart, it can be seen that 41% of the article focused on the science and ethics of CRISPR-Cas9, 35% of the articles focused on science alone and 24% focused on ethics alone.

Quantitative findings

Overall, the most (41%) articles focused on scientific and ethical aspects of CRISPR-Cas9, which represent balanced coverage of the two aspects and support the notion that it is a bioethical topic (Figure 6). More articles focused on science alone (35%) than ethics alone (24%).

Qualitative findings

Bioethics is defined as the ethics of medical or biological research. Codes that involved regulation, safety and human ethics were labelled as relating to bioethics. First, regulation was allocated to words concerning regulatory barriers, ethical approval and safeguards. Some

raw examples of this code state that the work should be conducted "under a robust regulatory scheme that ensures high scientific and ethical standards" (eNCA, 2015). Another example includes "everybody should calm down because there are regulatory safeguards already in place" (Health24, 2017) or "South Africa to fast-track investigations into existing gene-editing laws and guidelines" (SowetanLIVE, 2019).

Second, safety was coded to words relating to specificity, accuracy and efficiency. Some examples include "safety is a key question because gene editing is not always precise enough" (Health24, 2016). Also "researchers will next focus on testing the safety and improving the efficiency of the CRISPR-Cas9 process" (Health24, 2017). Another example includes experts cautioning that editing human embryos can generate "unintended mutations" or so-called "off-target effects" which can have a lifelong impact (TimesLIVE, 2018).

Lastly, human was assigned to words referring to human germline editing and designer babies. Some examples include "germline editing has been widely regarded as a line science should not cross" (Farber, 2015) and "edited genomes of human embryos have sparked a wave of panic in the international scientific community" (Health24, 2015) as well as "warnings against human gene-editing" (Citizen, 2019). Designer babies are also a main ethical concern as seen in "such technology could lead to so-called designer babies with desired features such as intelligence engineered into their genes" (Le Roux, 2017). Some also argue that designer babies "are already being born" (Citizen, 2018).

5.3.1.1 Regulation

Several articles discussed the regulation of CRISPR-Cas9 in terms of legislative measures, ethical guidelines and the importance of the implementation of such regulatory frameworks as discussed below.

In 2016 the British Human Fertilisation and Embryology Authority (HFEA) granted authorisation to edit the genomes of human embryos for research. Although China previously carried out CRISPR-Cas9 experiments, it was done in non-viable embryos which falls within their ethical guidelines (Vassena, Heindryckx, Peco, Pennings, Raya, Sermon & Veiga, 2016: 417). This was the first official authorisation of such research by a national governing authority. The application was accepted for developmental biologist Kathy Niakan from the Francis Crick Institute in London to edit healthy human embryos with CRISPR-Cas9 technology. The conditions of the approval were that the embryos should be destroyed after seven days since the research is focused on early development. Their decision also had a

global impact and emboldened other researchers to apply for ethical approval. This was observed in the news media articles analysed, where the United States also approved human embryo editing with CRISPR-Cas9 after Britain's announcement (Cribbs & Perera, 2017). They followed the same guidelines as the embryos were also only authorised to develop for a couple of days. In July 2018, the Nuffield Council on Bioethics suggested that it would be ethical to edit human embryos if it was in the interest of the overall wellbeing of the child (Brokowski, 2018: 118). The council recommended that such interventions should not exacerbate discrimination, division or disadvantage the community and would require rigorous ethical approval.

However, in 2018, ethical red lines were crossed when He Jiankui announced the birth of twins that he genetically modified using CRISPR-Cas9 technology. This incident sparked an outcry from the scientific community and the general public and resulted in major media coverage. After the announcement, several countries had to investigate their existing gene-editing laws and guidelines to improve the regulation of such technology. Sheetal Soni, a bioethical law lecturer from the University of KwaZulu-Natal, suggested in a news media article that South Africa and the global community should put effort into preventing irresponsible experiments from happening until safety, scientific, ethical and legal aspects were broadly discussed (Nair, 2019). The World Health Organisation also responded to this event by establishing an international expert panel to establish international guidelines for the use of this technology (Cyranoski, 2019). Xu Nanping, China's vice-minister of science and technology, said the experiment was a violation of Chinese laws and regulations and a transgression of their ethics (Edwards, 2018). Authorities in Beijing announced a moratorium on human germline editing. Scientists worldwide were critical towards He and stressed that making the announcement through YouTube was an inadequate way of announcing scientific findings emphasising the need for ethical approval and a thorough peer-reviewing process (Krimsky, 2019).

All the information mentioned above was reported in the news media, highlighting the newsworthiness of bioethical topics, specifically when ethical guidelines are violated. It can also be suggested that the regulation of bioethics is influenced by public discourse and information distributed by the media. Overall, the articles emphasised the importance of bioethical regulation in science to prohibit unregulated and unethical experiments.

5.3.1.2 Safety

One of the key issues emphasised in the articles concerned the safety of the technology, specifically efficiency and specificity. One such issue is the precise delivery of the editing system into the correct cells (Kempton & Qi, 2019). Proven safety is required for the research to gain permission to move to clinical trials. Experiments conducted in China on non-viable embryos sparked controversy in scientific communities, and the media reported it to the public. The results of the experiment deemed the procedure unsafe because several embryos were not altered correctly, and off-target effects were seen (Cyranoski & Reardon, 2015: 593). The media reported this and the cause for concern is valid. Unwanted and unforeseen alterations or mutations can cause congenital diseases from spina bifida to learning disabilities when the system accidentally cuts DNA similar to the target DNA or by causing double-stranded breaks (Kempton & Qi, 2019: 235).

In 2018, media reports about safety concerns raised substantially after the announcement of the gene-edited babies. The goal of the editing was to confer resistance to HIV by inserting a mutated variant of the *CCR5* gene known as Delta32 (D32) (Marx, 2019: 147). Although people without *CCR5* may be resistant to HIV, they are at higher risk for other viruses such as West Nile virus, hepatitis B and influenza since *CCR5* plays a vital role in the resistance of these viruses (Li & Shen, 2019). In June 2019, a study suggested that individuals carrying the D32 mutation face a 20% higher risk of early death compared to the global population (Wei & Nielsen, 2019). However, in October 2019, the study was retracted because of key errors in the replicability of the results (Callaway, 2019: 307).

It can be argued that the controversy associated with the safety concerns was the reason that the media deemed it newsworthy. Concerns in the articles were often accompanied by the fear that the rapid and uncontrolled use of the technology might outpace safety regulations and lead to unforeseen mutations with dangerous side-effects such as the case with the *CCR5D32* edited babies which the media specifically reported.

5.3.1.3 Humans or designer babies

CRISPR-Cas9 is mostly mentioned in the framework of human health and well-being in spite of several animal and agricultural applications. CRISPR-Cas9 technology in the context of health topics of human germline editing or so-called designer babies were primarily viewed as problematic and non-beneficial in the articles analysed. Given the current social and

ethical debate, the negative tone towards designer babies is not surprising. Supporting this, recent research on the public view of genetic engineering display less public support for germline engineering particularly regarding human enhancement (Funk & Hefferon, 2018: 3; Blendon, Gorski & Benson, 2016: 1408).

The greatest fear present in almost all the articles is the engineering of designer babies. Designer babies entail the idea that people can edit genes in such a way to achieve desired results such as improved intelligence, athleticism and appearance. Some argue that the misuse of the technology rather than prevention of disease may have serious social consequences. Designer babies are often associated with eugenics in the articles. However, George Church, a genetics professor at Harvard, argues that eugenics differs vastly from designer babies because eugenics entailed governmental sterilisation of citizens without their consent (News24, 2015). On the other hand, the decision to use CRISPR-Cas9 technology to improve health risks is a different situation.

Several articles suggested that designer babies could create a more significant socio-economic divide as only some will be able to afford the so-called designer baby treatment. However, these socio-economic advantages already exist in terms of pre/post-natal gene testing, nutrition, and education. Church suggested that health disparity should not be the focus; instead, efforts should be made to recruit funding to decrease the cost of the technology when it becomes available (News24, 2015).

Biomedical Professor George Seidel from Colorado State University argued that designer babies already exist by using pre-implantation genetic diagnoses (PGD) (Seidel, 2018). PGD is a process where cells from embryos are screened for several genetic abnormalities and parents can then choose embryos free from those abnormalities (Vermeesch, Voet & Devriendt, 2016: 644). Other news media articles argue that designer babies are a fictional idea because genes associated with hair or eye colour, height, weight, behaviour and intelligence are too complex to edit accurately. For example, there are 124 genes associated with hair colour and 111 were only recently discovered which makes the concept of designer babies with specific hair colour seem improbable (Hysi, Valdes, Liu, Furlotte, Evans, Bataille, Visconti, Hemani, McMahon, Ring, Smith, Duffy, Zhu, Gordon, Medland, Lin, Willemsen, Jan Hottenga, Vuckovic, Girotto, Gandin, Sala, Concas, Brumat, Gasparini, Toniolo, Cocca, Robino, Yazar, Hewitt, Chen, Zeng, Uitterlinden, Ikram, Hamer, van Duijn, Nijsten, Mackey, Falchi, Boomsma, Martin, Hinds, Kayser & Spector, 2018: 652).

The focus on designer babies in almost all the articles underline the fact that the media use or even exploit the news value of entertainment when reporting on human gene-editing. Although the popular idea of a superior designer baby is still a far-reaching one; it may capture the attention of the audience and spark interest in a public bioethical debate.

5.3.2 Creating expectations: Support or criticism?

This section aims to answer if the South African news media supported or criticised CRISPR-Cas9 technology.

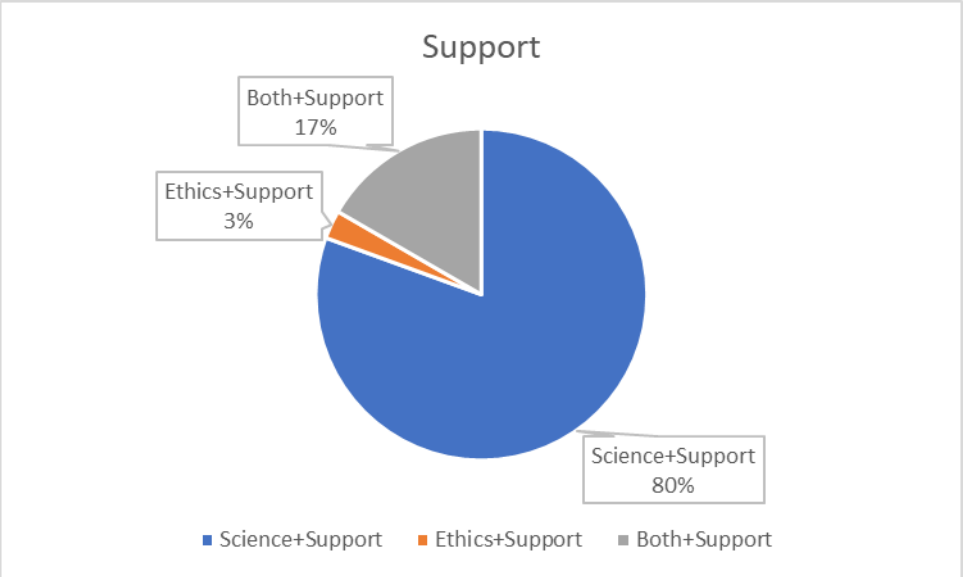

Figure 7. Representation of the type of article (scientific, ethical or both) supportive of CRISPR-Cas9 technology.

In this pie-chart, it can be seen that articles about the science of CRISPR-Cas9 were 80% supportive, articles about science and ethics were 17% supportive, and articles about CRISPR-Cas9 ethics were 3% supportive.

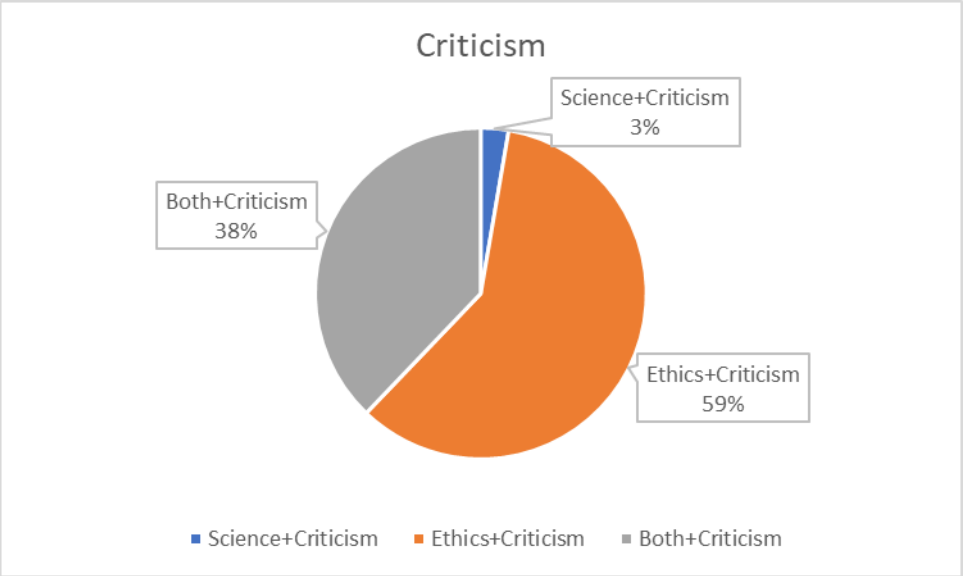

Figure 8. Representation of the type of article (scientific, ethical or both) critical towards CRISPR-Cas9 technology.

In this pie-chart, it can be seen that articles about the ethics of CRISPR-Cas9 were 59% critical, articles that discussed both science and ethics were 38% critical, and articles about science were 3% critical.

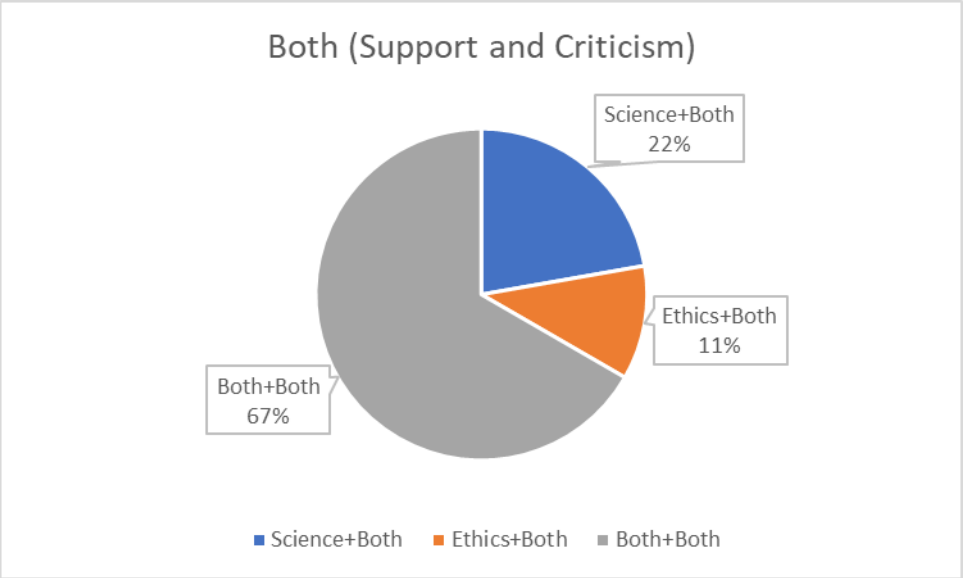

Figure 9. Articles supportive or critical towards the science, ethics or science and ethics of CRISPR-Cas9 technology.

In this pie-chart it can be seen that 67% of the articles about the science and ethics of CRISPR-Cas9 were met with both support and criticism, 22% of articles about science were both supportive and critical, and 11% of articles about the ethics of CRISPR-Cas9 were both supportive and critical.

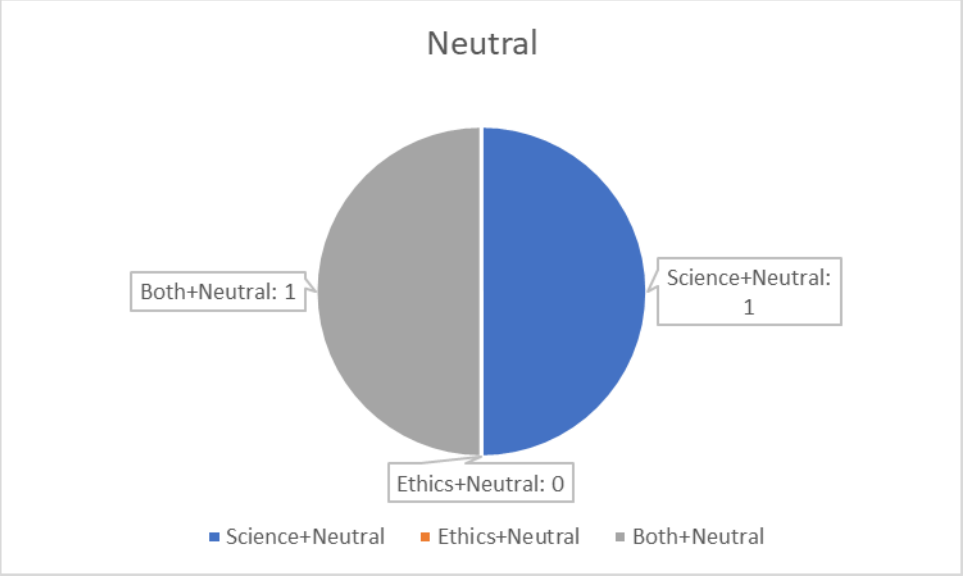

Figure 10. Articles neither supportive or critical toward science or science and ethics of CRISPR-Cas9 technology.

In this pie-chart, it can be seen that one article about the ethics and science of CRISPR-Cas9 and one article about the science of CRISPR-Cas9 was neither met with support or criticism.

Quantitative findings

Articles focused on the science of genetic engineering were mostly (80%) supportive, and articles focused on ethics of it were only supportive in 3% of the cases (Figure 7). This might be because CRISPR-Cas9 is such a ground-breaking technology and possible scientific applications thereof such as treatments or eradication of genetic diseases were frequently mentioned. CRISPR was presented overall as beneficial to health matters. The reason for the small percentage of ethical support is instances such as the Nuffield Council on Bioethics that support the technology provided that is used for the wellbeing of the patient.

Articles focused on the ethics of CRISPR-Cas9 were mostly associated with criticism (59%), but only 3% of the science-related articles were critical (Figure 8). The reason for this occurrence is that ethical topics are often controversial, and mainly because He Jiankui violated ethics of germline editing in the time of the study. Critical concerns were mostly toward germline modifications which may lead to designer babies and fear of unknown health consequences with the use of CRISPR-Cas9 technology.

Sixty-seven percent were both supportive and critical in the articles that focused on both science and ethics of CRISPR-Cas9 (Figure 9). These conflicting statements represent strong evidence for the existence of a debate in the public sphere. This also represents balanced reporting in terms of different stances towards CRISPR-Cas9. The contradictions seen indicate the uncertainty towards the technology because it is still in its infancy.

Only two articles were neither supportive or critical towards the science as well as the ethics and science of CRISPR-Cas9, and none were neutral (Figure 10). Therefore, neutrality was in the minority, establishing the fact that varied opinions exist towards CRISPR-Cas9 technology.

Qualitative findings

To examine the expectations created by the news media, the content (words, phrases, sentences) was either labelled as positive or negative. Positive codes involved words and phrases that support CRISPR-Cas9 technology such as “cure” and “solution”. Some examples of this code include phrases where the technology is described as “designed to fix mutations that cause the majority of human genetic diseases” (EWN, 2017) and “the potential to revolutionise medicine and could lead to the eradication of inherited diseases” (Allen, 2017; SowetanLIVE, 2018). It was also described as the scientific breakthrough of 2015 and remained one of the top 10 medical breakthroughs of 2017 as described by *Health24* (Wilke, 2017).

Negative codes were assigned to words related to fear or criticism of the technology. Some examples of the fear code include phrases such as “dangerous side effect— causing unintended mutations” (IOL, 2017). “There are growing concerns regarding unwanted mutations” and “potential side effects are still important challenges” (Le Roux, 2017). The criticism code was mostly associated with He Jiankui, and his experiment received an international barrage of criticism from the scientific community with several describing his experiment as “dangerous, irresponsible, crazy and premature” (Roxburgh, 2018).

5.3.2.1 Positive expectations

The positive expectations were stated under conditions of the possibility to cure several diseases, including cystic fibrosis, haemophilia, cancers, obesity, deafness, blindness, mental illness, and human immunodeficiency virus (HIV). Although some of these claims were

fictional statements, some successful animal studies found in the literature review were also mentioned in the articles. For example, the case where tyrosinemia was reversed in mice (Yin et al., 2014). Dystrophin levels were also restored in dogs with DMD, a genetic disease characterised by progressive muscle degeneration (caused by a defective gene responsible for producing the protein dystrophin) (Amoasii *et al.*, 2018).

There was also mention in the articles that the technology could stop world hunger by making crops less susceptible to climate change and grow in inhospitable environments to produce vitamin-rich foods (Song, Jia, Chen, Kong, Khattak, Xie, Li & Mao, 2016). The idea that it will stop world hunger is far-reaching. According to the Food and Agriculture Organization of the United Nations (2017), world hunger is a multifaceted challenge involving poverty, political instability, war and climate change. Although CRISPR-Cas9 might be a helpful tool in the improvement of crops, it cannot stop world hunger on its own.

These claims may instil positive expectations of CRISPR-Cas9 technology as a possible solution for numerous diseases. However, it can also be exaggeratedly positive, implying the presence of inappropriate science hype. CRISPR-Cas9 technology is still in its infancy and requires time to go through several clinical trials before its applications to humans are ethically and technically acceptable and feasible.

5.3.2.2 Negative expectations

Negative expectations were expressed under conditions of fear and criticism. One of the main fears is that CRISPR-Cas9 technology might create mutations leading to unwanted and unintended consequences. The fear that the reckless application of CRISPR-Cas9 might lead to designer babies, monsters or a modern form of eugenics is mentioned regularly in the news media articles. Fear of the unknown impact of the gene-drives on ecosystems is also mentioned. These fears are all valid because CRISPR-Cas9 is currently in a situation where fixing one problem has proven to spark another because the technology is not yet precise enough. Addressing these fears and concerns of the public and the scientific community should be as important as implementing regulations for the CRISPR-Cas9 technology.

The criticism in the articles was mainly against He Jiankui's experiment producing the first CRISPR-Cas9 engineered babies. Chinese authorities, institutions and the international scientific community condemned the use of the embryos as risky, unjustified, irresponsible, crazy, abominable, unacceptable, shocking, reckless, naïve, and disturbing. The flaws of his experiment were also highlighted in several articles, including failure to meet ethical

standards, lack of transparency, poorly developed protocol and inadequate medical indication. Feng Zhang, co-inventor of CRISPR-Cas9 technology, argued that the experiment should not have happened and does not represent science (TimesLIVE, 2018). Other articles expressed concern that his experiment would harm the reputation of other CRISPR-Cas9 gene therapy trials that are, in fact, following the correct ethical protocols (Almendrala, 2018). Since the criticism was mainly focused on He's unethical experiment rather than on the CRISPR-Cas9 technology itself, the percentage of criticism towards ethics of CRISPR should be placed in this context. The first-ever CRISPR-Cas9 engineered babies were born in 2018 without ethical approval, and this controversial event happened during the time of this study which generated high media coverage and subsequently skewed the criticism percentage.

5.3.2.3 Positive and negative: a contradiction?

In several articles, a positive statement of cure is contradicted by a negative one. For example, "it is a great tool, and it is promising, but it is also scary, we are not ready for *Gattaca*" (IOL News, 2017) and "it has been hailed as a cure for cancer and all forms of inherited disease but can have a potentially dangerous side effect – causing unintended mutations" (Shapiro, 2015).

This emphasises the tension between the promotion and encouragement of science and technology while at the same time recognising the ethical, social, legal and health risks that accompany its advancement. As previously mentioned, several of these statements are falsely positive as it is not yet a cure-all technology. The negative statements that follow are mainly about safety concerns regarding the unpredictability of its effects. The possibility of unintended mutations is connected to the frame of terrifying "Frankenscience" and designer babies. Fears of irreversible altering of the human race and negative consequences for all creatures and ecosystems are mentioned in the articles. This contradiction is expected because several uncertainties surrounding the technology exist. Furthermore, public debates about

these contradictions in the news media can become part of the broader bioethical debate that includes the scientific community and policymakers

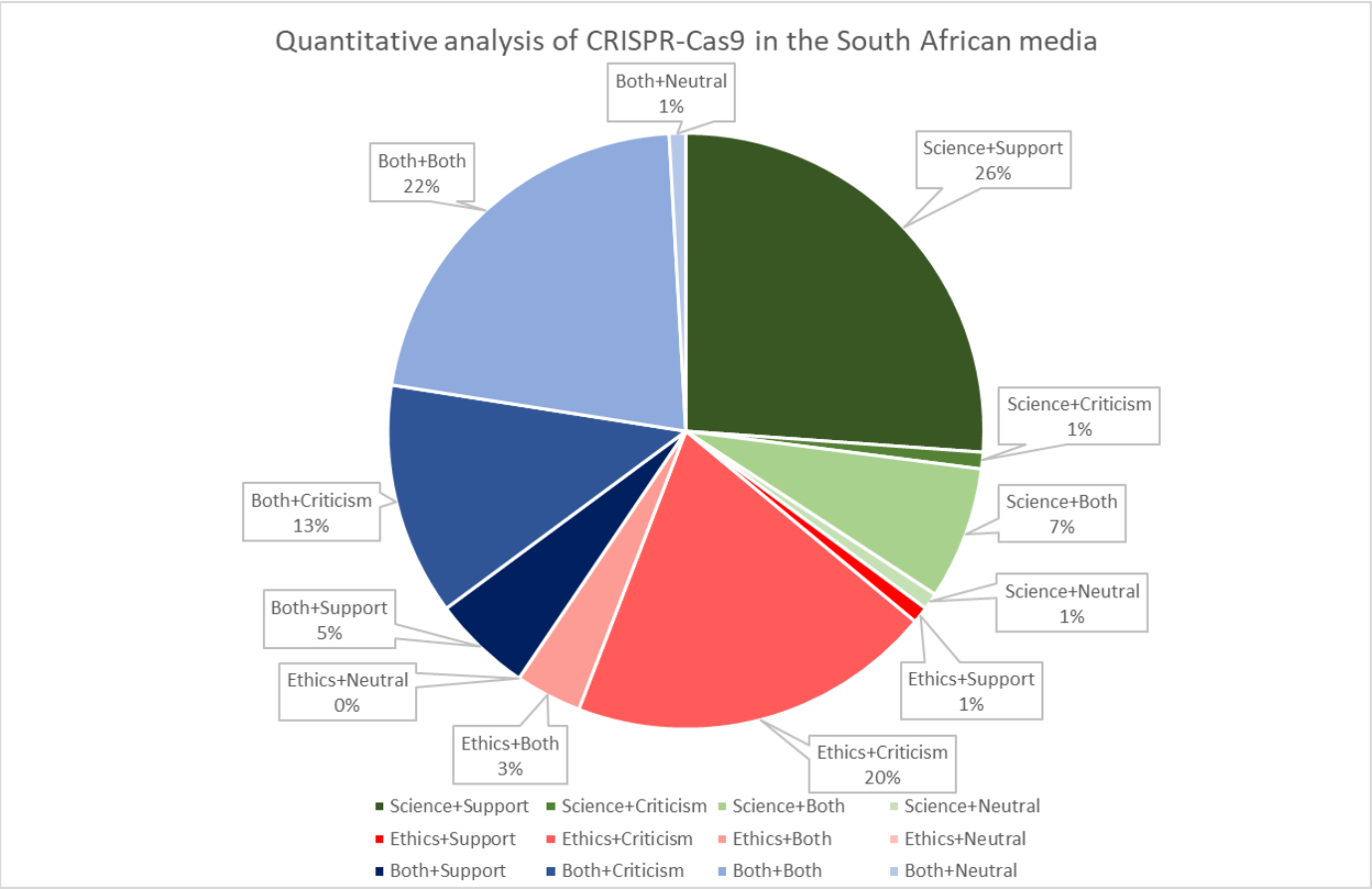

Figure 11. An overview of science, ethics and both in the context of support or criticism towards CRISPR-Cas9 in the South African media.

The results from the quantitative analysis show that most of the articles (41%) were about the science of gene-editing and the ethics thereof. A large percentage of the articles were about the science of CRISPR-Cas9 and associated with support (26%). It can also be seen that articles discussing ethics were never neutral (0%).

5.3.3 The role of framing

This section aims to investigate how framing played a role in the articles. Three distinct frames were seen in the articles, and their significance discussed below.

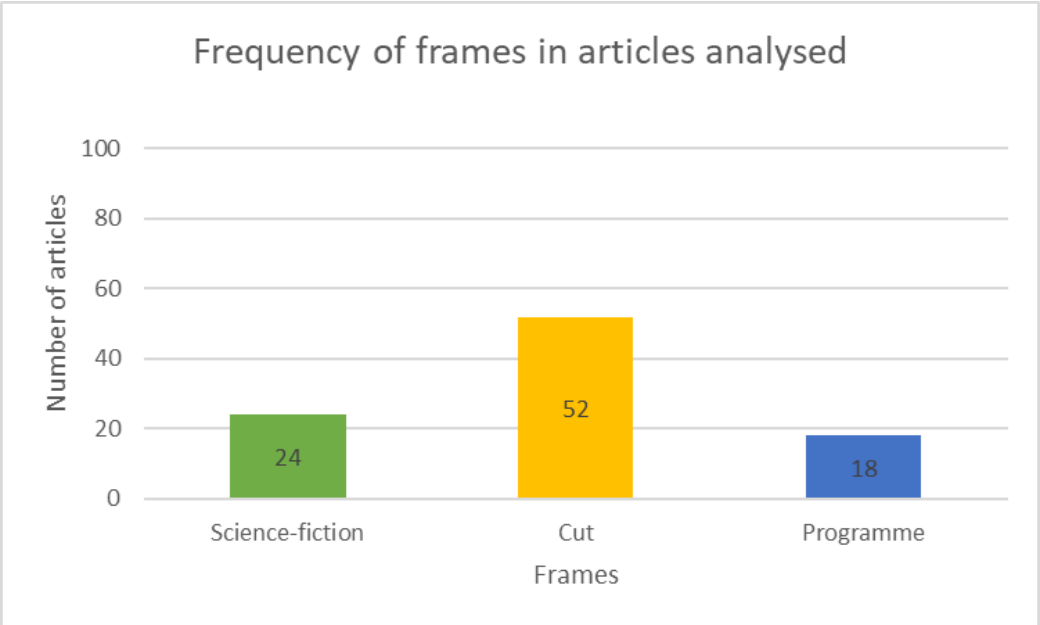

Figure 12. The number of times that articles mentioned frames of science-fiction, cutting (scissors) or computer programmes.

In this bar graph it can be seen that a frame CRISPR-Cas9 function of cutting genes was mentioned 52 times, and science-fiction related themes 24 times, and the technology in the context of computer programme functions 18 times.

Quantitative findings

The cutting frame was mentioned 52 times to explain the CRISPR-Cas9 system and the programme function such as “find and replace” to explain its mechanism was used 18 times. Science-fiction frames were mentioned 24 times and were often associated with the possibility of designer babies (Figure 12). These results display the important role that the theory of framing played in the articles.

Qualitative findings

Framing is used by the media to focus attention on particular events by placing them within a sphere of meaning that the audience can relate to. The label of framing was assigned to phrases and words where a reference was made to science-fiction or the action of cutting or functions of computer programmes. Science-fiction related words include superheroes, robots, monsters, Frankenscience and science-fiction books or films. Some examples include "others have described it as terrifying Frankenscience" and compared it to the "futuristic thriller *Gattaca"* (IOL, 2016) (Shapiro, 2015b).

The cutting code referred to words such as molecular scissors, trim and snip, cut and paste. These words were used to explain the technology for example "it is like using molecular scissors to cut and paste DNA" and "that allows scientists to snip a specific target sequence on a mutant gene" (Health24, 2017).

The programme code refers to commands such as "delete" or "find and replace" or "cut and paste" used in human-computer interaction. This inter-process communication is a way of transferring data through a computer's interface and was also used to further explain how the CRISPR-Cas9 system works, for example, it operates similar to a word-processing programme that can "find and replace defects" in genes (eNCA, 2015).

5.3.3.1 Science-fiction

The use of Frankenstein as a metaphor was mentioned in the articles. Firstly, He Jiankui was referred to as China's own Frankenstein because of his so-called monstrous experiment (Edwards, 2018). The reference to Frankenscience also arose from an article that discussed potential human-animal hybrids where human organs are grown in pigs by using the CRISPR-Cas9 system (IOL News, 2016). The experiments sparked major controversy as scientists, ethicists and laypersons said that it would cross ethical boundaries between humans and animals. However, the researcher conducting the experiments aimed to grow viable organs to use them as exact genetic copies of the patient organ; thereby removing the challenge of transplant rejection (Whitworth, Lee, Benne, Beaton, Spate, Murphy, Samuel, Mao, O'Gorman, Walters, Murphy, Driver, Mileham, McLaren, Wells & Prather, 2014: 2). A biotechnology company also hopes to avoid the so-called Frankenfood label when using CRISPR-Cas9 to genetically engineer crops (EWN, 2018).

Another frame mentioned was *Brave New World*, a science-fiction novel by Aldous Huxley, where the government modified the genetics of citizens to deepen divides between social classes, creating superhumans and slaves (Shapiro, 2015a). The comparison of CRISPR-Cas9 engineered babies to a futuristic thriller film, *Gattaca,* was used similarly because in the film some children were engineered to be perfect and disease-free while others were subject to menial labour (Shapiro, 2015b). Another article mentioned that the rapid development of the technology might turn *Homo sapiens* into so-called *Robo sapiens* emphasising the dehumanising element often associated with genetic engineering (Van Niekerk, 2013). The reference to superspecies such as Superman, Batman and Wonder Woman is closely associated with the designer babies code (Van Niekerk, 2013).

Reporters have used science-fiction frames of Frankenstein and monsters since molecular genetics emerged in the 1970s in order to express fears of runaway science. Today, in public communication, journalists still resurrect these metaphors to translate science in a culturally meaningful way. The idea that these science-fiction characters can become a reality by the use of CRISPR-Cas9 may be used to add entertainment value and to popularise the stories. These frames also provide a further contextual frame for the audience directed towards the understanding of the revolutionary impact of the technology.

5.3.3.2 CRISPR-Cas9 as molecular scissors or a computer programme

In order to explain the science behind CRISPR-Cas9, almost all the articles referred to the system as molecular scissors that cut defective DNA and paste it in the correct sequence. The system has also been compared to a biological word-processing programme that can find and replace genetic typos highlighting its precision and ease of use. These frames may serve as an explanatory tool, but the disadvantage is that they act as selective filters, emphasising some aspects of the technology while obscuring others. For example, the oversimplification of the technology and protocol can further evoke the fear of accidental cutting of genes with subsequent off-target effects. Therefore, while frames can often improve the public's understanding of technologies such as CRISPR-Cas9, it can also undermine, mislead and misrepresent it. Ultimately, frames are used as metaphors which can affect the way we structure our perception of certain public and scientific issues.

By their choice of framing metaphor (science-fiction, molecular scissors and computer programmes), science writers, scientists and public communicators guide certain ideas about

the nature and significance of the science or technology topic at hand, as well as their subsequent confines, effects and consequences.

5.4 Summary

This chapter gave an account of the findings of the content analysis by providing an excerpt of the primary and secondary cycle coding and graphs from the quantitative data. The findings were then analysed and discussed to answer the research questions of the study. Firstly, the news media analysed focused mostly on both the science and the bioethics of CRISPR-Cas9 (Figure 6). The news media were supportive of CRISPR-Cas9 in terms of scientific applications and critical in certain ethical aspects thereof (Figure 7, Figure 8). The theory of framing played a role in the articles as three distinct frames were observed, namely science-fiction frames, cutting frames, and computer programme frames. The frames were mainly used as an explanatory tool but could also misrepresent the technology with ideas of science-fiction (Figure 12). In the next chapter concluding remarks on these findings will follow along with the limitations of the study and recommendations for future research.

Chapter 6: Conclusions, Limitations and Recommendations

6.1 Introduction

This chapter explains how the aim of the study was fulfilled. Firstly, the findings of the literature review and theoretical framework are discussed in relation to the findings of the study. This was done in order to establish how these findings contradict or confirm findings in the existing literature. Then, the research questions are answered, and final concluding remarks are made to show how the study extended, problematised and contributed to our understanding of how the media reports the bioethical debate about the CRISPR-Cas9 gene-editing technology. Lastly, the limitations in terms of time, place and conditions are considered, and suggestions are made for future research on this topic.

6.2 Conclusions

The goal of this study was to investigate how the South African online news media reported on a new gene-editing technology such as CRISPR-Cas9 (from 2013-2019). From this, the study aimed to answer which frames were used through quantitative and qualitative content analysis.

In the literature review, it was established that the CRISPR-Cas9 system is a unique DNA cutting mechanism with significant implications for the genome-editing field. However, despite the advancements and applications seen in the literature, the technology is still in its infancy with regards to safe delivery, off-target effects, and ethical regulation. The field of bioethics today is not only confined to the clinic but forms part of the public domain. The mass media is a vital source of scientific information to laypersons and assist in public awareness and understanding of science. It is also the principal domain in which bioethical issues come to the attention of the public. The way in which the media portray these debates can influence how these controversies are defined, symbolised and possibly resolved through shaping better regulatory policies. Journalists have been criticised for inaccurate science reporting. However, recently, more scientists have had positive experiences with journalists because of an increase in evidence-based journalism. Bioethics requires strict compliance with specific ethical codes with an emphasis on minimising risk and maximum protection of participants. These rules and regulations are also embedded in laws and policies and overseen by ethical committees and review boards. Despite these firm ethical boundaries, He Jiankui violated these regulations and produced the first CRISPR-Cas9 gene-edited babies in 2018.

This incidence was seen in a harsh light and caused the announcement of an international moratorium on all clinical uses of germline engineering till all scientific, technical, medical, ethical, moral and societal conditions are met.

In the analysis, it was established that the selected South African news media placed considerable focus on both the bioethics and science of CRISPR-Cas9 (41%) because it is a complex scientific system which requires explanation and is categorised as a bioethical topic because of its significance to regulation, safety and possibly human health impact. A subsection of bioethics was the regulation of this system, and it was deduced that regulation of CRISPR-Cas9 is influenced by authorities such as institutions or ethical committees and the law. It was noted that if one researcher obtains ethical approval, it emboldens other researchers worldwide to apply for such approval. The public discourse sparked and conveyed by the media has a vital role in providing a platform for scientists to motivate scientific development but also to note the importance of regulatory frameworks. Another subsection of bioethics is the safety concerns with regards to CRISPR-Cas9's efficiency, specificity, and outpacing safety regulations. These safety concerns often gave rise to far-reaching ideas of designer babies. The controversy or entertainment-value associated with safety concerns and designer babies might have been why the news media deemed it newsworthy. However, it is crucial to address these concerns, and the news media provides a platform for it. Therefore, the media is an active participant in the bioethics of CRISPR-Cas9 and may subsequently create a media-shaped reality thereof. This phenomenon may not only influence the public's perception but also ethical policies and regulations.

To answer the question whether the media supported or criticised CRISPR-Cas9 a comparison was made to see if the media were supportive, critical or both supportive and critical towards the science or the ethics of CRISPR-Cas9 or perhaps both the science and the ethics. The quantitative results showed that the articles were mostly (80%) supportive of the science of CRISPR-Cas9 because of its claims to be a ground-breaking cure-all technology. The articles were sometimes overly optimistic, creating inappropriate science-hype which may be misleading to the audience. This highlights a call for more evidence-based journalism, as noted in the literature review.

Articles about the ethics of CRISPR-Cas9 were minimally supportive (3%) in cases where ethical committees approved germline editing. Most of these articles (59%) were critical with regards to safety concerns, fear of designer babies and He Jiankui's ethical violation. The

ethical criticism was primarily associated with He Jiankui's case and generated high media coverage. Therefore, it must not be concluded that the criticism is against CRISPR-Cas9 as a scientific technology but rather the misuse thereof as seen in the case of He Jiankui.

Articles that dealt with science and ethics of CRISPR-Cas9 were mostly supportive and critical (59%) which indicates a bioethical debate, balanced reporting and the uncertainty of the technology. The tension that articles create by supporting and criticising aspects of CRISPR-Cas9 underlines the need for promotion and encouragement of science as well as the recognition of ethical, social, legal and health risks. These contradictions or debates are a vital part of news media, especially for introducing a broader bioethical debate which involves scientific communities, ethical authorities and the public.

Framing played an essential role in the articles as the molecular scissors frame of cutting DNA as an aid to the explanation of the CRISPR-Cas9 system was mentioned 52 times. Similarly, the biological word processing metaphor to computer programme functions were mentioned 18 times. These explanatory frames often oversimplify complex science and can evoke fear and further safety concerns. Although the cutting and programme frames were used as tools for explanation, they emphasise some aspects of the technology while masking others. These frames may ultimately undermine, mislead and misrepresent the CRISPR-Cas9 system. Science-fiction frames such as Frankenscience, futuristic films or books and the idea of designer superheroes were also observed in 24 articles. These metaphors have been used in the news media since the 1970s to translate science in a culturally meaningful way and to add entertainment value and popularise scientific topics. However, the choice of these frames may guide negative ideas about the nature and significance of CRISPR-Cas9 and confine it to fictional ideas which further evokes fear and distract from its possible benefits.

Overall, the study extended knowledge in the field of science and bioethics reporting in the South African news media. Certain problems were observed with regards to evidence-based science journalism as not enough attention was given to specific research applications or methodological aspects of CRISPR-Cas9 and therefore it is difficult for the audience to separate science hype from evidence-based research. The bioethical debate is evident in the articles analysed and showed the tension between the promotion of science but also the caution towards the risks of CRISPR-Cas9. These risks include technical, ethical, legal, and social aspects that need to be addressed before it will be ethically acceptable to use the technology on the human germline. The media play a pivotal part in facilitating the public

debate and encouraging public discussion about the governance of the technology. The theory of framing also contributed, and the use of these frames deemed useful as an explanatory tool and to make science culturally and socially meaningful. However, the choice of frames should be carefully considered because they determine how others perceive CRISPR-Cas9 technology. The news media should perhaps not resurrect old frames such as the Frankenstein myth but instead develop new meaningful metaphors together with evidence-based science journalism.

6.3 Limitations

This study was not without limits as certain conditions could be improved. The study was limited to a South African perspective. The study was part of the fulfilment of a degree and confined to a period of one year, and with increased time, the study would be strengthened. The researcher compensated for this by choosing articles over six years to expand knowledge in that way. The use of qualitative content analysis as a method lends itself to subjectivity because no input was given from the journalists who were responsible for writing the articles. However, the use of quantitative analysis further supported the qualitative results. The study was also done at the peak of the He Jiankui scandal and may have exaggerated criticism towards CRISPR-Cas9. Nevertheless, this was noted in the findings and placed in context.

6.4 Recommendations

For future research, it would be interesting to do the study across a larger geographical area and include several types of media such as radio, television and social media which are also important contributors to the public understanding of science. Furthermore, it would be interesting to add a survey component to determine public attitude towards CRISPR-Cas9. Interviews can also be conducted with reporters and scientists and their role reflected in the articles to investigate the issues more objectively.

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