Anita ETALE*, Sabelo D. MHLANGA*

ETHICAL ISSUES IN NANOTECHNOLOGY RESEARCH: PERCEPTIONS OF RESEARCHERS AT THE UNIVERSITY OF SOUTH AFRICA

Abstract: Nanotechnology research in South Africa is progressing rapidly. However, as with other regions of the world, less is known about researchers' perceptions and understanding of the ethical issues related to nanotechnology (EIRNT). We mapped the views of nanotechnology researchers (graduate students, postdoctoral scholars, technicians and professors) at the University of South Africa, on the ethical aspects of their work. Information was collected on factors including interest in, and perceptions of the importance of ethical issues, ethics in laboratory conduct and in communication (hype or downplaying of risk), as well as the willingness to learn more about EIRNT. We found that although a majority of researchers were sensitive to EIRNT and believed that these were important to consider, some disagreed with this view while others were unsure. Furthermore, most students did not consider themselves well informed about EIRNT but were willing to invest time in learning more. Interestingly, only 50% of respondents thought the use of hype was completely or somewhat unethical.

Key words: *Nanoethics, laboratory safety, hype, nanotechnology risk perception, ethical issues related to nanotechnology research (EIRNT)*

INTRODUCTION

Nanotechnology (NT) refers to technologies that involve the manipulation of matter at the nanometre (nm) scale (1–100 nm). It is projected to revolutionize the 21st century with among other things, smaller, lighter and faster devices that use fewer raw materials and less energy. NT has already enabled a number of commercial products including dust and sweat-repelling mattresses, biocidal wound dressings, water and dust resistant sprays used in the building industry as well as cosmetics personalized according to race, age and physical activity[1]. Despite all these and other potential benefits, nanotechnologies also have negative human

* Nanotechnology and Water Sustainability Research Unit, College of Science Engineering and Technology, University of South Africa

health and environmental impacts. Carbon nanotubes have been shown to have asbestos-like effects on human lung cells [2,3] and Song et al. [4] reported pulmonary inflammation and granulomas amongst female workers exposed to polyacrylate nanoparticles for 5–13 months. There are also concerns over „Trojan-horse" effects arising from their interactions with other pollutants [5,6]. Baun et al. [7]reported that in the presence of carbon nanotubes, phenanthrene was 60% more toxic to daphnids. As such, the practice of NT brings to bear important ethical issues ranging from environmental and personal protection to the manipulation of biological life and concerns over individual privacy [8,9]. Suggestions have also been put forth of a „nano-divide" i. e. where nanotechnology intensifies the gap between the rich and the poor and questions regarding who will benefit or lose out from global advancements in NT [10]. There are also issues regarding (i) access to knowledge and possible limitations from broad patents taken out by researchers in developed nations where more research takes place due to greater funding, (ii) the affordability of crucial NT-enabled solutions especially in the medical domain, and (iii) the diversion of investment from low-tech solutions [11].

There is therefore increasing consensus that NT researchers need to be aware of the ethical issues around their work. Dowling et al. [11] in the Royal Society report (2004) recommended that due to the potential for benefit and risks posed by NT, researchers should give thought to the wider implications of their work and research students should be able to demonstrate an awareness of the ethical issues associated with their research. Despite this, a recent U. S study found that most (80%) of NT researchers in U. S universities and NT research centres felt they were not well-informed about ethics in NT [12]. On the ethics of laboratory conduct e. g. conducting hazardous procedures and taking prohibited shortcuts, the study found that 72% of respondents thought it was unethical to perform hazardous procedures without informing their bench-mates. However, only ~19% would report shortcutting behaviour to management and 24% would not take no action such as trying to dissuade the offending member from taking the prohibited shortcut. Nonetheless, almost three fifths of respondents believed that clear ethical guidelines were necessary for responsible conduct of nanotech research.

NT research in South Africa has progressed rapidly in the last 10 years, especially in the fields of water treatment, energy and drug delivery [13–17]. However, as in other regions of the world, far less is known about researchers' perceptions of the ethical issues around nanotechnology. Using measures from the U. S. study, this investigation mapped the views of NT researchers at the University of South Africa (UNISA) on issues including:

1. The ethical aspects of NT and of their research e. g. in laboratory conduct;
2. How well informed on ethical issues in NT researchers considered themselves;
3. Whether researchers were willing to learn more about the ethical issues in NT.

METHODS

Data for this study were collected using paper and pencil surveys in March and April 2016. The survey was made up of two parts: the first (Part A), probed respondents' general and specific views of ethics in NT research, and the second (Part B) collected demographic, educational and occupational information. Thirty five (35) respondents were researchers from the Physics and Chemistry departments as well the Nanotechnology and Water Sustainability Research Unit (NanoWS) at the University of South Africa. They consisted of graduate students, postdoctoral scholars, technicians and academic staff (doctors and professors).

The first four questions of the survey, (Questions A 1 to A 4), probed general attitudes towards ethics in NT research using Likert-type responses *e. g.* strongly disagree, somewhat disagree, agree as much as disagree, somewhat agree, strongly agree. Question A5 probed attitudes on specific issues including ethics in laboratory practice, the use of hype to influence decisions and the responsibility to anticipate and alert authorities on unethical downstream applications. Other issues that were probed include ethics in research and development e. g. the role of commercial interests, the responsibility to report on the possibility of dangerous downstream applications by various practitioners, ability for self-regulation and necessity for clear ethical guidelines for practitioners.

NOTEWORTHY FINDINGS

This section presents some of the results of this study, in particular, the levels of awareness and interest in EIRNT, general attitudes towards and interest in EIRNT, and, finally ethics in laboratory conduct and communication (hype).

(i) Levels of interest in and awareness of EIRNT

Levels of interest in and awareness of ethical issues in nanotechnology research were probed directly using the following questions:

— How interested are you in ethical issues related to NT?

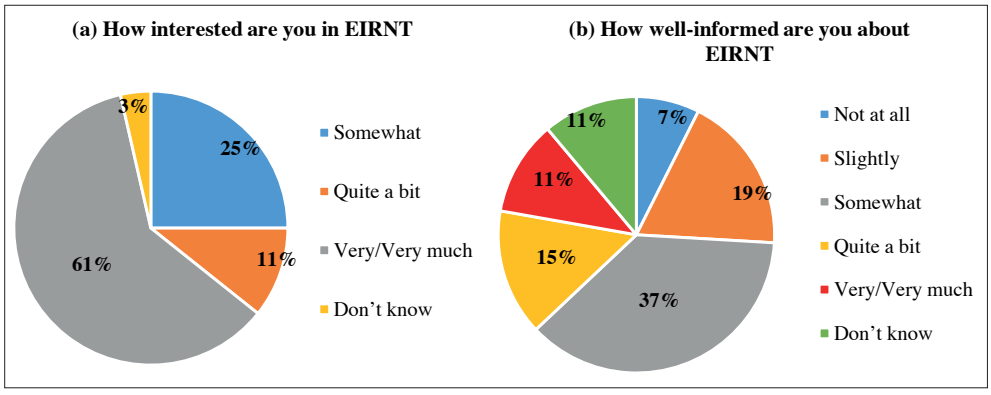

Figure 1. Levels of interest in and awareness of EIRNT amongst survey respondents

— How well informed do you believe you are about ethical issues related to NT?

The responses showed that up to 97% of respondents were interested in EIRNT (Figure 1 a). Despite this, only 26% felt they were sufficiently informed about EIRNT; most felt they were either somewhat or only slightly aware if these issues. As most respondents were students, this finding provides a glimpse of future nanotechnology professionals with respect to awareness and consideration of ethical issues. If there is consensus that researchers need to consider EIRNT around their work, then ways of inculcating ethics in their training are worth looking into. Fortunately, such an exercise is likely to be positively received because 81% of respondents were willing to invest time in learning more about EIRNT and up to 97% believed, strongly or somewhat, that the study of ethical issues needed to be a standard part of the education of future scientists and engineers.

(ii) General attitudes towards and interest in EIRNT

The following four questions were used to gauge general attitudes towards and interest in EIRNT among respondents:

A1: „'There are significant ethical issues related to nanotechnology." To what extent do you agree or disagree with this statement?"'

A2: „How interested are you in ethical issues related to nanotechnology?"

A3: „How important do you believe it is that ethical issues related to nanotechnology be considered?"

A4: „In your opinion, how does the importance of the ethical dimension (E) of the nanotech field compare with the importance of the scientific dimension (S) of the nanotech field?"

Sixty one percent (61%) of the respondents felt strongly that there were significant ethical issues related to nanotechnology while a further 7 and 14 % agreed somewhat or were „on the fence" regarding the issue. On the other hand, 14% disagreed somewhat or strongly, and a further 4% were not aware of any ethical issues (Figure 2a). Interest in ethical issues was recorded to be high: 57 % of survey re-

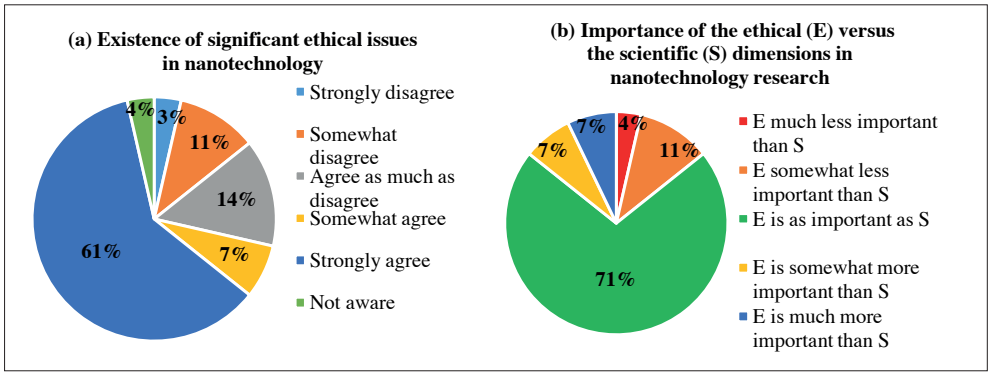

Figure 2: Respondents' views on (a) the existence of significant ethical issues in nanotechnology and (b) the relative importance of ethical and scientific dimensions in NT research

spondents were very interested, while 18% were quite interested and a similar fraction somewhat interested. Nearly two thirds of the respondents regarding felt that it was very important for ethical issues be considered in NT research while a further 18 and 11% felt that ethical issues merited quite some or moderate consideration, respectively. The final question in this introductory section (A 4) attempted to gauge how nanoscientists weighed ethical issues against the scientific issue which were more central to their everyday practice. Seventy one percent (71%) regarded ethical ad scientific issues as having equal importance but 15% felt that the former was of either somewhat or much less importance than the latter (Figure 2 b).

These results give a preliminary picture of the views of survey respondents on ethical issues in NT and lay the background to views on specific issues. The fact that most respondents had a personal interest in EIRNT is encouraging because it implies that the surveyed NT researchers give thought to the wider implications of their work and not just the scientific aspects of it. It also means that fertile ground exists for further sensitization and inculcation of EIRNT.

(iii) Ethics in laboratory conduct

Ethics in laboratory conduct were assessed by several questions including A 5 A and D below. The former question addressed ethics by researchers in managerial positions i. e. those that direct work / productivity in the laboratory while the latter spoke to individuals' conduct in laboratory processes.

A5(A) A nanotech scientist demands that her/his research assistant produce the results the scientist expects, quickly and at any cost.

A5(D) An experienced nanotech researcher, never involved in a lab accident, plans to carry out in the lab for the first time what s/he realizes is a potentially hazardous procedure, and to do so without informing the workers who share her/his bench.

Sixty five percent (65%) of survey respondents thought it was either completely or somewhat unethical for a laboratory manager to demand that an assistant produce specified results at any cost (Figure 3 a). This finding was encouraging because it showed that despite the fact that a major proportion of respondents were students, they understood what could or could not be demanded of them. Of interest, however, is the demographic that thought that such a demand was either completely ethical (4%) or that ethics was irrelevant to the action. Perhaps the latter group would be swayed otherwise if they were sensitized on ethical issues. Eighty six percent (86%) of respondents reported that they had never taken an ethics course.

On the other hand, three quarters of respondents thought that conducting a potentially hazardous experiment without informing other researchers on the same bench was completely unethical, even if the person conducting the experiment had no record of lab accidents to their name (Figure 3 b). Once again, a small minority felt that this was ethical or that ethics was irrelevant to the action and while this is a cause for concern, it serves to further strengthen the argument for ethics education.

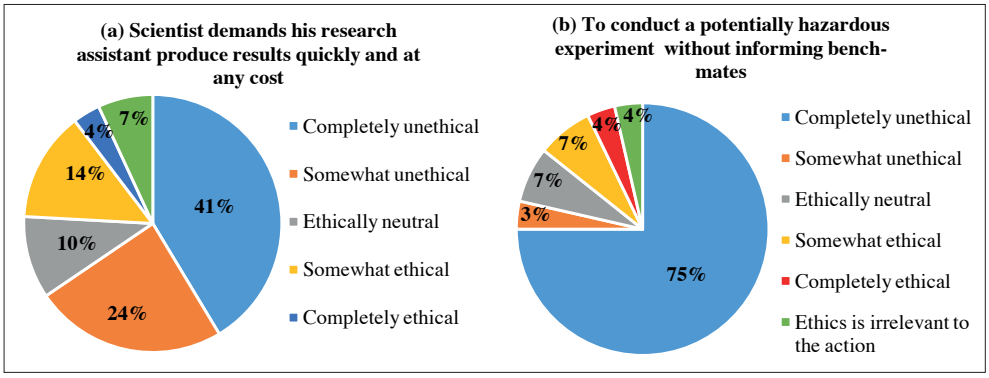

Figure 3: Respondents' views on ethical issues around laboratory conduct

Question A 7 was then asked to gauge laboratory culture and approaches to unsafe laboratory practice i. e.

A 7: For several weeks, a nanotech lab researcher has been taking a relatively safe, timesaving shortcut in doing her/his work. This shortcut clearly violates published laboratory procedures. So far, no unfortunate results have occurred because of this behavior. Other lab users know that s/he is taking the shortcut.

Which of the following do you think would be the two most likely responses to this situation by users in your nanotech lab? (Place „1" in front of the most likely response in your lab and „2" in front the second most likely response in your lab.)

_____A Users would report the individual to lab management.
_____B Users would cease having professional contact with the individual.
_____C Users would approach the individual and try to persuade her/him to stop taking the shortcut.
_____D Users would start taking rule-violating shortcuts of their own.
_____E Users would take no action and the situation would continue unchanged.
_____F Users would make this situation a matter of public debate at the lab.

Respondents were thus being asked to expose the general culture of their laboratory with respect to unsafe practices by nominating actions they thought fellow laboratory members would take. The question was qualified by the mention of factors which would resonate with many laboratory researchers i. e. that the procedure was relatively safe and that it was taken to save time. Respondents were given several options and asked to choose the most likely and the second most-likely action that they would take.

Most respondents felt that the offending researcher would be persuaded to change their ways as a first measure and that reporting the individual was only a second option, perhaps if the offender would not be persuaded. An interesting finding was the demographic that felt that nothing would be done about it and or that other members in the laboratory would start taking their own shortcuts (Figure 4).

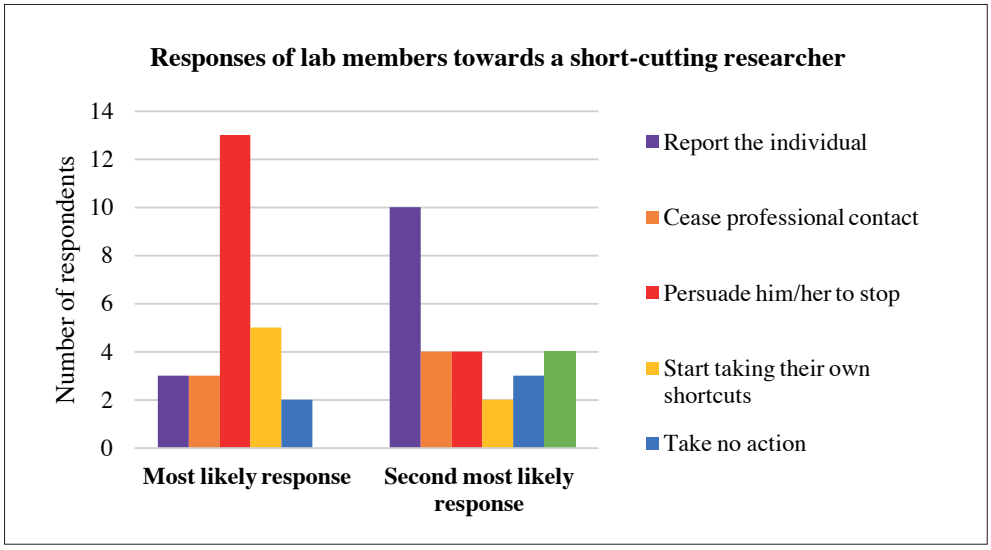

Figure 4: Responses of laboratory members towards a short-cutting researcher

This is of concern because these two actions particularly would only act to entrench the shortcutting behaviour because then „everyone is doing it". These results are similar to those reported in the McGinn study [18] where persuasion was the most likely first response (43.8% of respondents) but a substantial fraction (24%) reported that the culture was such that no action would be taken. Only 19% felt that the offender would be reported to management. Perhaps therefore, the overriding response offenders, despite the differing settings, would be to avoid confrontation.

(iv) Hype in communication

Hype in communication may be applied in various scenarios e. g. in funding proposals or to convince member of institutional and parliamentary committees of the merits of an application or proposed project. Such claims as „being able to transform life as is currently known" and „being used to cure currently incurable diseases" have been associated with NT. While there may be some truth to them, the time frames sometimes linked to them may make these claims hype. We asked respondents whether the use of statements that may be considered more of hype that actual fact was ethical. Question A 5 (J) interrogated the whether it was ethical for a researcher writing a funding proposal to describe the benefits of her/his project as greater than s/he expects them to be. Only 18% of respondents thought that such an action was completely unethical. The majority (32%) felt that it was only somewhat unethical and 25% felt that the issue could be looked at either way *i. e.* ethically neutral. The rest (24%) felt that such action was somewhat or completely ethical. Perhaps such a result speaks to (i) how researchers view ethical issues when project funding is at stake; some may be willing to say anything to secure funding and (ii) how researchers respond to questions on ethical issues when

the risk of harm is indirect *i. e.* as opposed to a dangerous procedure in the laboratory. Researchers, however, need to be persuaded that both issues carry significant ethical weight.

CONCLUSIONS

In conclusion, this survey of NT researchers yielded encouraging results especially in terms of their receptiveness to EIRNT. Thus, despite not being particularly well informed about EIRNT, NT researchers at UNISA believe that these should be a standard part of their training and are willing and eager to learn more. This should be seen as an opportunity for action in order to ensure that well-rounded NT researchers.

Instruction on EIRNT is also likely to convince those who are currently neutral concerning certain ethical issues as well as those who hold improper views e. g. not informing lab bench mates about dangerous procedures or taking one's own shortcuts in response to others' shortcutting. We hope that this work lays a foundation for the inclusion of some form of instruction to NT researchers at UNISA and nationwide.

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