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PERCEPTION AND INFLUENCED FACTORS TOWARDS STEM CELL TECHNOLOGY IN THAILAND

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Abstract

The stem cell technology is one of emerging medical technology that has gained attention from public especially patients seeking for advanced treatment. There are many concerns about stem cells in different aspects. Until now, there are limited studies on how people perceive and accept stem cell technology especially in Thailand market. This study aims to identify any factors that influence the perception of public toward stem cell technology in Thailand. Quantitative method was conducted through survey online questionnaire among Thai population. 113 questionnaires were analyzed with descriptive and inferential statistics techniques. Results reveal that many factors influenced the stem cell technology perception but not religious belief as previously reported in other countries. Thai society relies on knowledge than familiarity to set a perception which is in contrast to other societies. The public perception on stem cell technology requires media attention level of public and reliability of media sources and the trustworthy key persons such as scientists (support by university not private) and medical doctors as the key persons to communicate the technical information. With right information and communication, the public will perceive benefits of this technology and use it to build the right perception on stem cell technology. These factors can be adapted by government and private sectors for preparation of public and building the right perception toward stem cell technology.

Introduction

Stem cells are undifferentiated cells commonly found in multicellular organisms; they have the ability to renew themselves through cell division and can be differentiated into a wide range of specialized cell types. When scientists first successfully extracted stem cells from human embryos in 1968, there is a hope that these malleable cells can ultimately be "programmed" to replace damaged bodily tissues. This breakthrough consequently created a widespread expectation that through the use of these embryonic cells, we could effectively tackle such life-threatening diseases as Alzheimer's or diabetes, as well as make possible recovery from unrecovered injuries such as spinal cord injuries. During this past few years, this breakthrough of stem cell research has reached the exciting stage of offering the prospect of restoring normal function to a much wider variety of tissues damaged by serious disease or injury than could have been contemplated just a few years ago. The presses published articles related stem cell therapies in early phase as future of medicine, and there is widespread of biotechnology startups, joint ventures, and pharmaceutical companies around the world targeting on developing new therapies based on stem cells.

Problem statement

There are a much unknown need to be addressed before this promising new medical area will applicable. There are many concerns about stem cells in different aspects, while scientific community is on the quest to decode the unknown related to stem cells such as the most suitable source of stem cells, how to obtain pure populations of the desired types of differentiated cells, and the knowledge needed to organize and retain stem cells in required stage in order to yield the right cell types for effective therapy. The society has additional concerns that cannot be ignored include the ethical issue and public perception toward stem cell technology. Whether a fair description or not, this idea would seem to be particularly relevant for issues involving complex and unfamiliar science and emerging technology. Developments in such new scientific areas as nanotechnology, genetically modified (GM) foods, or stem cell research involve novel knowledge claims, ideas which many people may not have confronted previously. Although, many observers have assumed that in case of science-related controversies, enhancing public scientific understanding and knowledge will bring public opinion on these topics closer to the same level of the scientific community, the real scenario is much more complex because these debates involve values and expectations, not purely scientific facts (Nisbet, 2005). Especially, stem cell research is emerging science and there was few of science- and technology-related issues have sparked as much public attention as cell research and therapeutic cell therapy due to its direct benefit change the future of healthcare.

Moreover, another aspect that plays an important role in the perception of public on this sensitive issue is some Christian conservatives idea which holds the "embryos are human beings created in God's image and worthy of full moral protection from the moment of conception" believe (Nisbet & Goidel, 2007). The stem cell controversy is widely seen as a battle between religious and scientific values. Interested groups, advocates, and policymakers on both side of the debate have taken advantage of the new finding and news to against each other. Furthermore, the effectiveness of stem cell therapy in patients is another diversity viewpoint that still unclear for public understanding.

This complex environment involved with various factors results in a different level of perception of public toward stem cell research and therapeutic cell therapy; it plays an important role in country-specific policy on stem cell usage and readiness of market on therapeutic cell therapy. Most of the related researches on the perception of the community toward stem cells technology were a study in western and developed countries with higher level of scientific knowledge among the population, and also with different religious beliefs and cultures. This research question of this study is

What are the factors influence the perception toward stem cells technology in Thailand?

The aim of this paper is to understand public perception of Thais toward the stem cell technology, the factors such as familiarity, religion, media influence, trust, and interpersonal communication.

Literature review

Definition of stem cells & stem cell technology

Stem cells are basic cells of all multicellular organisms having the potency to differentiate into a wide range of adult cells. Stem cells, whether they occur in the body or in the lab, must contain two characteristics; self- renew (generate perfect copies of themselves upon division) and differentiate (produce specialized cell types that perform specific functions in the body). The promise of stem cells as new tools for benefiting human health resides in these two properties that allow production of unlimited quantities of required cell types for use in therapeutic purposes or transplantation (EuroStemcell, 2013).

Beyond this definition, any cells possess two characteristics are considered as stem cells classified into two types, based on the range of specialized cells they can generate. Tissue or adult stem cells are found throughout the body, they function to maintain the organ or tissue in which they reside, throughout the lifespan. Most rapidly renewing tissues are maintained by stem cells, with the notable exception of the liver, which is maintained by specialized liver cells called hepatocytes. Under normal physiological conditions, each type of tissue stem cell only generates cells of the organ or tissue system to which it

belongs: the blood (hematopoietic) stem cell generates blood; the skin stem cell generates skin, and so on. An exception is the mesenchymal stem cells, which can generate bone, cartilage, and muscle (Bianco et al., 2013). However, while the mesenchymal stem cells have generated much valuable research field, it has also attracted controversy. Pluripotent stem cells, in contrast, have the potential to generate any type of cells found in the body. Pluripotent stem cells are generated in the laboratory by capturing or recreating cell types that exist only transiently during embryonic development and have not been identified in the adult body. There are currently three types of pluripotent stem cell, each generated by a different route: *Embryonic stem (ES) cells* are derived from early- stage, pre- implantation embryos, and were the first type of pluripotent stem cells to be discovered. *Epiblast stem cells* are a type of pluripotent mouse stem cells derived from a slightly later stage of embryonic development than mouse ES cells. *Induced pluripotent stem (iPS) cells* were discovered in 2006 using mouse cells, just a year later, this finding was replicated in human cells. The iPS cells are generated from specialized cells by using a technique called "reprogramming". This groundbreaking work was awarded the Nobel Prize in Physiology or Medicine in 2012. Researchers have rapidly adopted iPS cells for study and application.

With unique characteristics of stem cells on regenerative abilities, there are many potential usages of stem cells in research and clinic. In term of research, studies of human embryonic stem cells will provide useful information regarding complex events during the human development process. This is related to turning genes on and off to trigger undifferentiated stem cells to become the differentiated cells with a specific form of tissues and organs. A more understanding of the genetic and molecular controls of these process may yield information about how serious medical conditions, such as cancer and birth defects, arise and potential to offer new strategies for cure. (National Institutes of Health).

However, the most important potential application of human stem cells is the generation of cells and tissues that could be used for the treatment of diseases. Today, donated organs and tissues are often used to replace ailing or destroyed tissue, but the need for transplantable tissues and organs far outweighs the available supply. The ability to direct differentiate into specific cell types of stem cells offers the possibility of a source of replacement cells and tissues to treat diseases including macular degeneration, spinal cord injury, stroke, burns, heart disease, diabetes, osteoarthritis, and rheumatoid arthritis. With this knowledge, scientists, medical practitioners, and societies are speculating about the possibility of advance in the treatment of injuries and life-threatening diseases and generates new therapy field which is referred as cell-based therapy, regenerative or reparative medicine (National Institutes of Health, 2015b).

Public perception towards stem cell technology

Considering stem cell technology as emerging technology, which is technology that radical new, fast growth, and perceived on its capability of changing the status quo. It could be understandable that assessment of public attitudes toward it may not be possible at this point of emerging, because of low levels of awareness and knowledge of general public toward new technology. However, narrow focusing on scientific knowledge of public when examining attitude toward emerging technologies will measure only one aspect of how people develop opinions and attitude toward new technologies. Most of emerging technologies which general public have little or no direct experience, the attitudes and perceptions toward new technologies are made on little information as they think is necessary to make a decision on that issue, or based on cognitive and heuristic decision making (Scheufele & Lewenstein, 2005).

If we consider adoption of any innovative technology, the process occurs as a continuous and slow as sequential step starts from initial knowledge of an innovative technology, to form an attitude toward it, to reaching an adoption decision. This can be considered as diffusion process which influence by innovation itself, communication channels, time, and social system (Rogers, 1983) . This technology diffusion process can be seen as the cumulative or aggregate result of series of individual calculation that weight the incremental benefits of adoption of technology against the cost of change, or risk. The early phase of adoption of any technology which involves the initial knowledge on technology and beginning to form an attitude toward it is the critical phase and influence by other factors as well.

Focusing specifically in term of emerging technologies, there are many studies aim to find the factors that affected public perception on emerging technology similar to stem cell technology as described here.

Knowledge and familiarity

People are afraid of the " unknown" . Higher levels of knowledge of science are often assumed to enhance people' s understanding of associated risk and benefit and result in more optimistic attitudes, in contrast, skepticism about emerging technology is often believed to come from lack of knowledge and familiarity. There is a study shown that level of scientific knowledge is associated with positive attitudes toward science (Sturgis & Allum, 2004). (Cobb & Macoubrie, 2004) found that greater familiarity with nanotechnology is associated with more positive perceptions of benefits versus risks. However, there are a number of studies find that knowledge contributes little to people' s positive perceptions of science (Nisbet & Goidel, 2007). Some findings even suggest that higher levels of science literacy negatively contribute to public perceptions of new technology, for example, (Cobb & Macoubrie, 2004) test knowledge of nanotechnology and find that a large percentage of surveyed

respondents could not even answer one true or false question correctly.

However, a lack of factual information does not mean an individual cannot form an opinion on a science- related controversy. Sometimes familiarity is a more important factor influence on public attitudes and perception toward emerging technology than specific knowledge of scientific facts.

Religion influence

Although, the stem cell therapy is considered to be the miracle cure for life-threatening diseases such as Alzheimer's, diabetes or other serious injuries. However, the source of stem cells generates the concern to society as it may involve with the definition of other human being's life. The definition of life in religious concept can play an important role to society acceptance on this new technology. For example, the Christian conservatives believe on "embryos are human beings created in God's image and worthy of full moral protection from the moment of conception". This belief interferes the progress of stem cell technology in countries with a strong belief in Christianity and results the other sources of stem cells are being investigated that do not require the destruction of human embryos. Despite interfering on country's policy level toward stem cell technology, religion also plays an important role in public perception on stem cell therapy as well (Liu & Priest, 2009). There was previous report that intensity of religious worship is negatively associated with the public benefit perceptions of stem cell research and remains the most important factor in fostering public reservations about emerging technologies (Liu & Priest, 2009). While another in- depth study among Protestants and Catholics subjects by (Nisbet, 2005) reported the strength of religious belief ties to institutions and frequency of church visit have negative effect toward support of research.

Media influence

Media influence in public opinion has been a debate for decades. Media can perform a strong role in shaping public perceptions on highly technical or scientific issues. Especially, in a society that most members of the public will not have much experiential knowledge to draw from about these subjects, creating increased dependency on information from the media (Ball-Rokeach & DeFleur, 1976). Numerous studies have demonstrated that media serve as a key factor for the public to understand biotechnology and other scientific-related issues (Nisbet, 2005); (Nisbet & Goidel, 2007); (Scheufele & Lewenstein); (Eyck, 2005).

Trust in key persons

There is a theory that the trust could be a strong factor in shaping public attitudes toward the emerging technologies. (Lee, Scheufele, & Lewenstein, 2005) found that previous research has focused on a variety of trust variables, including trust in business executives or government, trust in information sources, trust in laws and regulations, trust in scientists, and trust in citizen groups.

Trust can be predictive of the general public's attitudes toward science controversies. To a great degree, the level of public risk and benefit perceptions associated with these emerging technologies reflects a number of trust people place in important social factors.

The example of the influence of trust on public perception toward emerging technologies is American society, Americans has traditionally placed a high value on science and technology. The American public trust in science can be reflected in the fact that science tends to be idealized "as an ultimate authority". Although scientific fraud and misconduct are frequently exposed in media, it does not seem to hurt science's reputation as a "pure and dispassionate profession". There was reported that trust is an important factor in shaping people's opinion about nanotechnology, with people tending not to believe that big businesses can protect them from risks (Cobb & Macoubrie, 2004). There is a finding report that scientists are often regarded as more persuasive information sources (Eyck, 2005). (Lee et al., 2005) observe from their study that public trust in scientists better predicts general support for nanotechnology than trust in science.

Another study in Australia examined the public opinion on stem cell research found that people participated in the research less likely to approve on stem cell researches, if the research was conducted by the scientists received funding from private sectors. The respondents were more accepting of publicly funded stem cell research because university scientists are trusted more, and that this trust is partly dependent upon a perception that they are more concerned with the public good than private scientists are (Critchley, 2008).

The different types of trust might produce differential effects on public perceptions of novel technology. Trust should be further differentiated since each area of science and technology might trigger completely different concerns. For example, GM foods might raise public health concerns, nanotechnology might make people worry about privacy, and stem cell research involves specific health and moral concerns (Nisbet, 2005).

Interpersonal communication

Another factor that might affect the perception of stem cell technology is interpersonal communication. Despite the fact that mass media are widely recognized as extremely important information providers and play an important role in shaping our attitudes toward many social issues, especially in the case of issues related to science where other sources of information may be in limited supply, interpersonal communication is also important and has often been argued to be even more important (Liu & Priest, 2009).

Interpersonal communication may reinforce by media. Based on the reinforcing model which that the media provide the public with discussion content and stimulate interpersonal communication (Ball- Rokeach & DeFleur, 1976). Specific to the stem cell

technology, the reinforcing model may help to explain the interaction between media and interpersonal communication in forming public opinion. Prior to exposure to media coverage of stem cell controversies, the issue would be unlikely to spontaneously arise and few relevant interpersonal discussions are expected to take place. As past findings show that media generally highlight more benefits than risks associated with stem cell research, we expect that interpersonal discussions tend to revolve around the same theme and would tend to reinforce positive media effects on attitudes in most cases.

Perceived risks and benefits

Risk and benefits of risky activities are positively correlated in the real world, people in pursuit of various benefits face some degree of risk. Because of this reason, the risk and benefit play an important role in perception toward the acceptance of any innovation or emerging technology. There is an assumption that citizens have various levels of understanding of emerging technology related to scientific concepts provides an important tool which citizens can make sense about risks and benefits connected to emerging technology (Lee et al., 2005). People tend to perceive risk and benefit of risky activities as negative correlated or inverse relation, especially, in the area which its hazards and benefits still unclear. People tends to use the affect heuristics to guides their perception of benefits and risks, except the level of knowledge and expertise are developed (Sokolowska & Sleboda, 2015).

Conceptual framework

Knowledge from literature review related to the perception of public toward emerging technologies and stem cells was shown that there are many factors influence public perception. We identified six factors which have strong effect on public perception toward stem cell technology as; knowledge and Familiarity, religion influence, media influence, trust in key persons, interpersonal communication and perceived risk & Benefits. These factors and demographics are targeted on this study and be summarized as a conceptual framework in Figure 1.

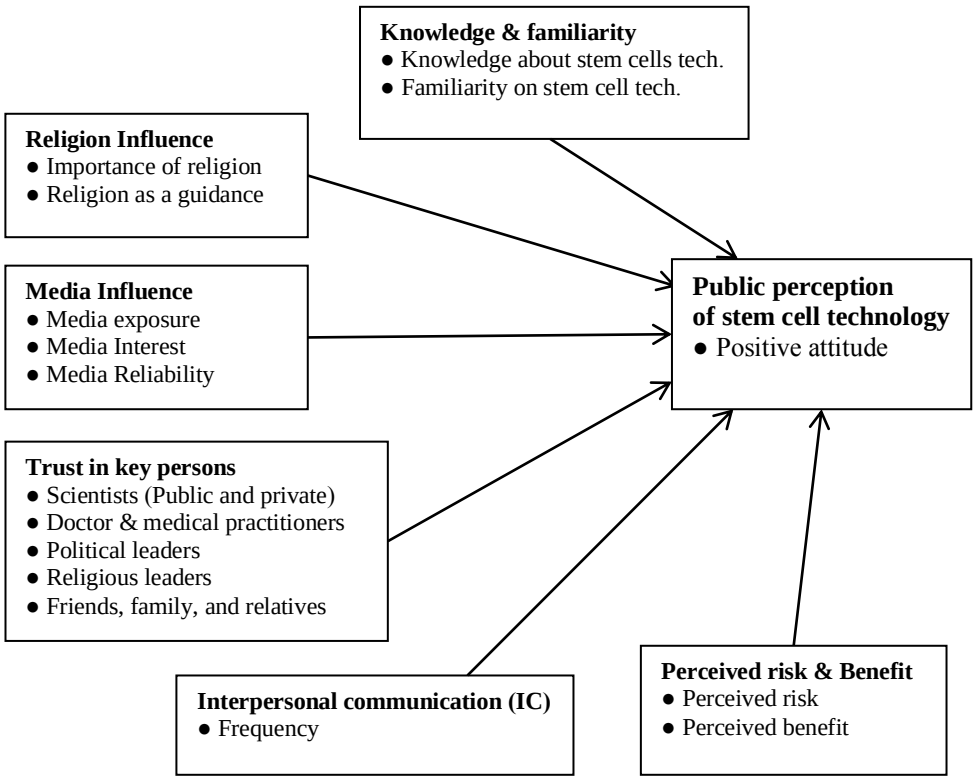

Figure 1 Conceptual framework of factors influencing perception on stem cell technology

Research methodology

This research will use quantitative method to explore the factors affect the perception of Thai community toward stem cell technology which provide the understanding of public perception on emerging technology such as stem cell technology.

The questionnaire was developed based on a concept from literature. To collect data in different aspects from participants, Likert-type questions were used to evaluate the opinion of respondents toward stem cell technology, with score ranges from 1 (minimum) to 5 (maximum).The additional questionnaire type such as conditional questions and multiple choice questions have been used as well in this study to gathering the clear opinion and in-depth details related to specific factors. The perception toward stem cell technology which measuring in term of attitude are collected in this questionnaire as dependent variable, due to the fact that this dependent variable was collected using Likert-type scale, the variable is fall into ordinal type.

The online questionnaire was distributed through different online channels such as social media networks, and email. Data was analyzed by SPSS® software. For ordinal type of data from dependent variable, parametric statistical analysis likes ANOVA, and linear regression could not be applied to this data set. It will be more appropriate to analyze this data with non-parametric analysis such as Kruskal-Wallis test for analysis of variance instead.

Research findings

Descriptive analysis

The survey reports the demographic profile of the respondents in this survey. Total sample size was n=113. From the total 113 respondents can be identified as 67 males (59.3%) and 46 females (40.7%), with age ranges in between 20 – 29 (35.4%), 30 – 39 (31.9%), 40 – 49 (10.6%), 50 – 59 (8.8%) and more than 60 years old (13.3%), respectively.

The highest education level of respondents is Bachelor degree (N=50, 44.2%), Master degree (N=55, 48.7%), and Doctor of Philosophy (N=8, 7.1%) with different education backgrounds. Almost half of respondents has education background in science and technology field (N=55, 48.7%). The rest are in business and finance (N=37, 32.7%), medical Science (N=8, 7.1%), language and art (N=7, 6.2%), and social science (N=6, 5.3%).

Perception toward stem cell technology

In this study, we measure the perception toward stem cell technology by measure the positive attitude of respondents toward benefit stem cell technology. The attitude was measured by evaluating the level of agreement that stem cell technology has more benefit. Overall the respondents agreed that stem cell technology has more benefit, with the different level of agreement. Half of respondents (N=56, 49.6%) highly agreed that stem cell technology has more benefit than risk. While 6.2% (N=7) of respondents still did not completely agree on this statement, the 31% (N=35), and 13.3% (N=15) of overall show the moderate and extreme level of agreement shown in Figure 2.

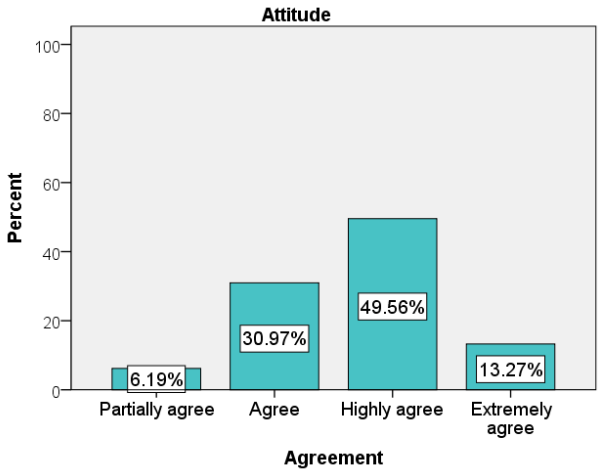

Figure 2 Perception toward stem cell technology based on attitude

Effect of factors related on perception toward stem cell technology

Effect of knowledge and familiarity

The knowledge and familiarity toward stem cell technology were evaluated using self-reported questions about their knowledge and familiarity on the stem cell technology. The responses from self-reported questions regarding stem cell knowledge explained that overall around 81 respondents (71.7%) claimed that they have knowledge about stem cells and 73 respondents (64. 4%) for stem cell technology.

An additional technical question set was set up as a following section in questionnaire to assess actual knowledge regarding stem cell and stem cell technology based on conditional questionnaire style, number of correct were collect and evaluated as actual knowledge on stem cell technology of respondents. The respondents actually have better knowledge on stem cells and stem cell technology than they claimed, considering the number of correct answers on question set. Around 8.9% of respondents (N=10) did not have or have few knowledges about stem cells and stem cell technology, while 33. 6% (N= 38) are in moderate level of knowledge and 57. 5% (N= 65) of respondents are considered as high to very high level as shown in Figure 3.

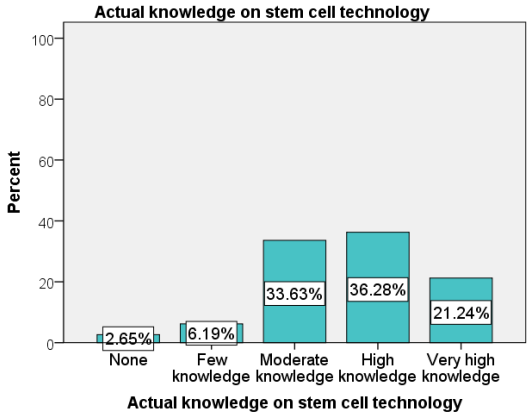

Figure 3 Actual knowledge on stem cell and stem cell technology

The familiarity was measured with a self-reported question. The analyzed result shown that 16.8% of respondents (N=19) considered themselves not familiar with concept of stem cell technology. Almost half of respondents (N=51, 45.1%) which is the majority group responded that they are somewhat familiar with this concept, and the rest 16.8% and 5.3% of total respondents are shown their familiarity level at moderate and high. However, none of respondent claimed that he/she has very high level of familiarity with this concept.

Knowledge and familiarity factors were test for their influence on perception on stem cell technology with Kruskal-Wallis H test. The result showed that there was a statistically significant difference in perception toward stem cell technology between group of respondents who had different level of knowledge on stem cell ($\chi^2(2) = 9.569$, $p = 0.002$) and stem cell technology ($\chi^2(2) = 4.445$, $p = 0.035$). Either the knowledge is about stem cells or stem cell technology, the group that responded in questionnaire that they possessed knowledge on both specific areas had more positive perception on stem cell technology than the group that not. But this was not related to the actual knowledge on stem cell and stem cell technology of respondents as there is no statistically significant difference between respondent groups with different actual knowledge level. Interestingly, the previous study on perception toward nanotechnology provided the similar result the what really affected the perception is how respondents say they know than what they really know or their actual knowledge about the technology (Cobb & Macoubrie, 2004).

Influence of religion

Previous studies reported that the public perception of stem cells are closely connected with religious belief and values, especially, how individual's institutional ties to religion. However, measuring of religious belief and personal belief ties to religion is sensitive for some respondents. Moreover, the demographic information such as

religious belief itself does not provide any level measure of the strength of individual's tie to the institution such as religion (Nisbet, 2005). The previous study suggested to measuring the religious belief effect in term of indirect questions such as how often of respondents attend the service or performing worship per week and how the respondents rely on religion as a guidance in life (Liu & Priest, 2009; Nisbet, 2005). In our case, we decided to measure this factor accordingly and frame it as the importance of religion and religion as guidance in life.

The result was shown in Figure 4, the respondents evaluated the religion as an important factor in their life in different level; there are 11.5% of respondents (N=13) who did not consider religion as important, while 18.6% (N=21), 33.6% (N=38), 27.4% (N=31), and 8.8% (N=10) considered religion as somewhat important, important, very important, and extremely important, respectively.

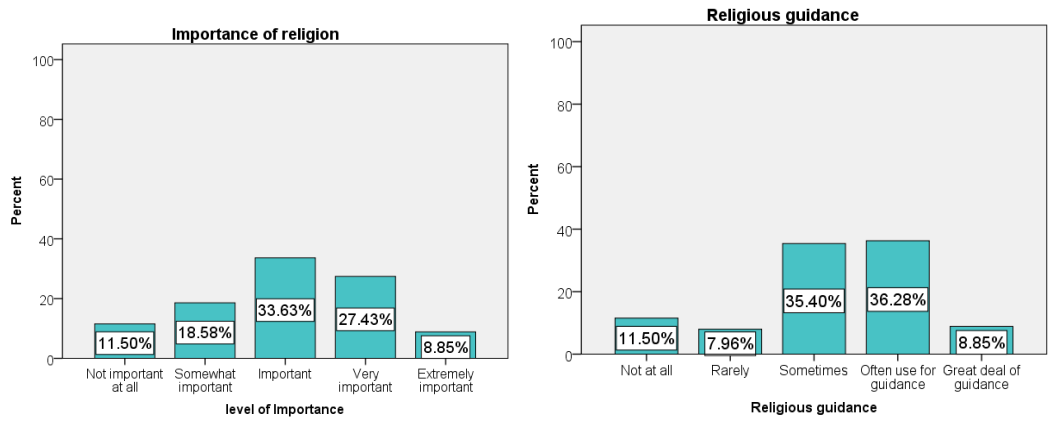

Figure 4 Importance of religion and religion as a guidance in day-to-day living

According to question evaluated the religion as a guidance in day- to- day living many respondents reported often usage of religion as a guidance (N=41, 36. 3%), but a roughly equal number (N=40, 43%) also indicated that they sometimes used religion as a guidance. So we can conclude that there are the same number of people who see this in opposite. The rest are 9 respondents (8%) that rarely use religion as a guidance in their living and 10 respondents (8. 8%) that considered religion as a great deal of guidance. Interestingly, the same number of respondents (N=13, 11. 5%) did not considered religion is important, are the same number of respondents who did not use religion as a guidance as well. However, we did not test that both groups composed of the same respondents or not.

The influence of religion on perception on stem cell technology was measured by evaluation the importance of religion and level of usage of religion as a guidance on day-to-day living. Result showed that both factors, importance of religion and

usage as a guidance, did not have any influence on perception on stem cell technology in our studied group ($p = 0.702$ and 0.459). Contrary to previous studies by Liu and Priest (2009) that the religious worship is negatively associated with the public benefit perception of stem cell research. We suspected that the inconsistency of our result with previous studies may cause by the difference in religious belief and values based on Buddhism religious belief, as previous report in demographics analysis section that more than 90% of our respondents has Buddhist religious belief.

Media influence

Media is another potential factor influencing attitude and perception of public on stem cell technology. We measured different aspects of media in this study as media exposure in term of frequency of news exposure, respondents' attention level on specific contents of media, and media reliability as three potential independent factors influence perception on stem cell technology.

Firstly, the exposure level of respondent to media was measured in term of frequency of news exposure per week. Overall 91% of the respondents (N=103) exposed to the media in different level. The 27.4% of respondents reported everyday exposure to the news on media, while the 3.5%, 6.2%, 5.3%, 17.7%, 14.2%, and 16.8% of respondents reported their exposure as 6, 5, 4, 3, 2, and only one day per week, respectively. Interestingly, there are 10 respondents which considered as 8.8% that reported themselves no exposure to any news on media.

Focusing on stem cell technology exposure to the respondents group, another question was examined their exposure to stem cell technology through media. The result was separated into two groups, there were 66.4% (N=75) of respondent reported themselves previously being exposed to news and information about stem cell technology. In opposite, 33.6% of respondents (N=38) claimed never previously exposed to the stem cell technology news and information.

The media exposure in this study was evaluated by two variables, the frequency of media exposure, calculated from number of the day per week that the respondents were exposed to media, and the exposure on stem cell technology through media. Both variables were analyzed with Kruskal-Wallis H test for their effect on perception on stem cell technology represented by attitude. The result showed that there was no statistically significant difference between groups with different exposure to media ($p = 0.078$), this mean that the frequency of exposure to media did not influence the perception, same as the exposure to stem cell technology through media also did not have any effect ($p = 0.545$). We can conclude that frequency of media exposure and exposure on stem cell technology on media did not have any effect on attitude toward stem cell technology perception. This finding was in opposite with a previous study done by Liu and Priest (2009) that the exposure to national TV news showed a weak positive influence on benefit perceptions on stem cell research which researcher claimed that it was in contrast with some studies (result not shown in literature). However, the researcher explained that this effect was influence by media

attention of the respondents but did not have any additional data support. We decided to involve in both effects by further conducting the additional set of questions regarding media attention in the next section.

Figure 5 explained the variation of attention level of respondents according to the topics. In term of general topics related to science and technology, medical technology and breakthrough, and policy related to new scientific development; Most of respondents showed the moderate attention level over these topics. However, the respondents had less attention in specific topic related to stem cell technology.

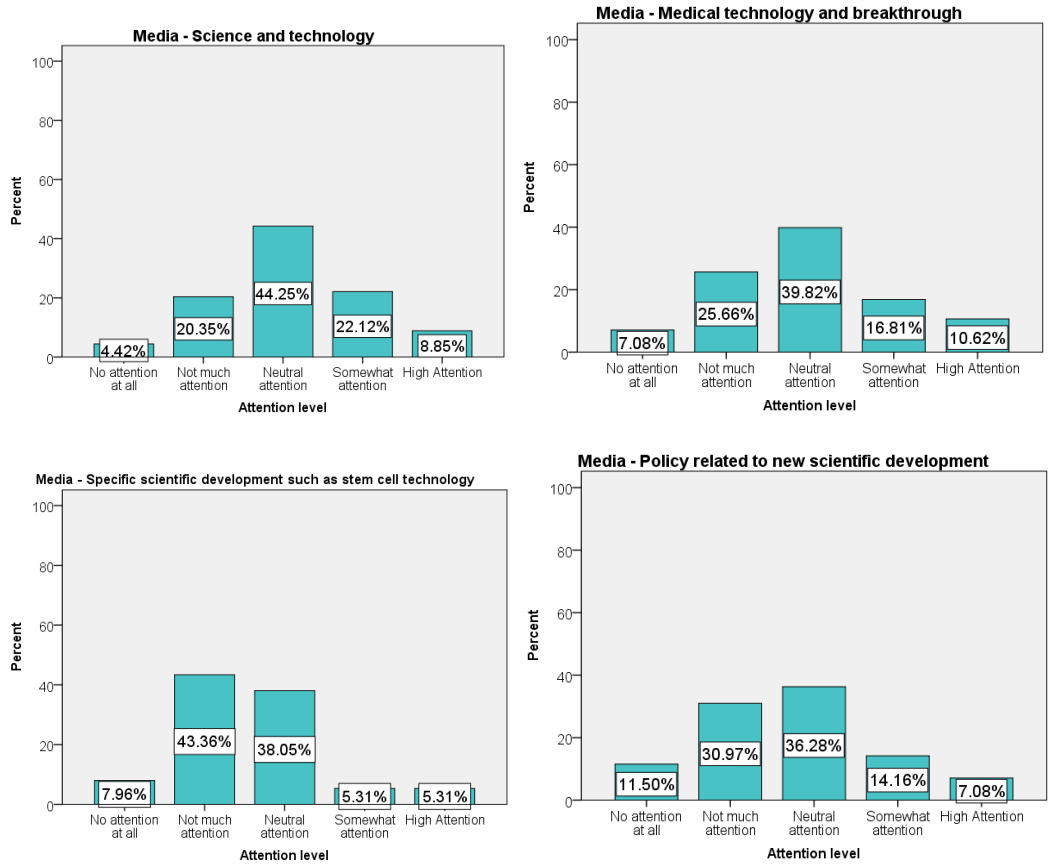

Figure 5 Attention level of respondents on specific topic related to stem cell technology

Lastly, we would like to examine that the reliability of the media sources and its influence. The reliability of media sources was tested for its influence on people' s perception toward stem cell technology. The reliability level of seven media sources consisting of TV news, documentary, radio news, internet and

social media, article in newspaper, articles in magazine, and article in scientific journals were collected and evaluated. Only two media sources, documentary and article in scientific journals, showed the influence of its reliability on perception of stem cell technology at $\chi^2(2) = 15.639$, $p = 0.004$) and $\chi^2(2) = 15.569$, $p = 0.004$, with a mean rank according to data reported. This mean that the level of reliability of stem cell technology information on documentary and article in scientific journals is affected the perception on stem cell technology.

Effect of trust in key persons

Even though, trust is understudied variable in the area of public understanding. There was previous study trust on few key actors such as scientists, political leaders, and religious leaders as variable affected the public understanding of stem cell controversy (Liu & Priest, 2009). In comparison with previous study, we examined trust in similar key persons or key opinion leaders in stem cell technology field such as scientists, political leaders, and religious leaders. In addition, we separated the scientists into two groups according to their funding sources (government and private sector funding source) as the source funding may affect the trustworthy of scientists (Critchley, 2008). Moreover, we suspected that the potential influencers such as the doctors and medical practitioners or family, friends, and relatives may influence the opinion through interpersonal communication were added into this study.

The trust in each key person was measured as opinion on creditability in term of stem cell technology information source. The summary was shown in

Table 1. The scientists funding by government, scientist funding by private sectors, and doctors and medical practitioners were rated as credible key persons in term of stem cell technology information, with 41.6% (N=47), 37.2% (N=42), and 36.3% (N=41), respectively. The trust level in another potential key person such as friend, family, and relatives, was somewhat credible (N=55, 48.7%) but less than the first group. However, the key persons who considered as influencers for policy area such as political and religious leaders were considered least in term of creditability, 47.8% (N=54) and 48.7% (N=55).

Table 1 Summary of trust in key persons in term of stem cell technology information

Key persons	Creditability				
	Not credible at all	Somewhat credible	Credible	Very credible	Extremely credible
Scientists (Government)	2.7% (N=3)	21.2% (N=24)	41.6% (N=47)	22.1% (N=25)	12.4% (N=14)
Scientists (Private sector)	5.3% (N=6)	30.1% (N=34)	37.2% (N=42)	22.1% (N=25)	5.3% (N=6)
Doctors or medical practitioners	3.5% (N=4)	19.5% (N=22)	36.3% (N=41)	30.1% (N=34)	10.6% (N=12)
Political leaders	47.8% (N=54)	36.3% (N=41)	14.2% (N=16)	1.8% (N=2)	0% (N=0)
Religious leaders	48.7% (N=55)	39.8% (N=45)	9.7% (N=11)	1.8% (N=2)	0% (N=0)
Friends, family, and relatives	24.8% (N=28)	48.7% (N=55)	22.1% (N=25)	3.5% (N=4)	0.9% (N=1)

The effect of trust of different key persons on perception on stem cell technology was analyzed. The result from Kruskal- Wallis H test elucidated there was a statistically significant difference in perception on stem cell technology between different level of trust in scientists (funding by government) and trust in doctors and medical practitioners at $\chi^2(2) = 13.486$, $p = 0.009$) and $\chi^2(2) = 18.031$, $p = 0.001$. However, the trust in other key persons such as scientist funding by private sectors, political leaders, religious leader, and friends, family and relatives did not have influence on perception on stem cell technology. The influence of trust on scientist funding by government was previously reported having influence on perception on stem cell technology (Critchley, 2008; Liu & Priest, 2009).

Critchley (2008) did the comparison on effect of trust on scientists received funding support from government and private sector source and found the similar result that the trust on public scientists are higher than private scientists. Because of perceiving of public scientists were more likely to produce benefits accessible to the public, in contrast that the private scientists were more self-interest. However, the religious leaders which previously reported making significant contribution to people's attitudes related to stem cell research (Liu & Priest, 2009), did not

have any influence on public opinion on stem cell technology in our study. The political leaders who supposed to involve with stem cell technology in term of policy. But the trust in political leaders did not show any influence on stem cell technology.

As we introduced some new key persons to this study, the trust in doctors and medical practitioners are factor that we were interested to study. Due to the fact that, the stem cell technology involved with the disease treatment and medical practices, the result showed that the trust in this new key person had influence on perception on stem cell technology as well. Although, there was no other study that examine the trust in this group that we can used for comparison. But we believe this will be the effect of level of involvement of this new key person group in term of knowledge on medical usage of stem cells and related healthcare policy.

Friends, family and relatives were grouped as another key person group that supposed to influence the perception by interpersonal communication. The trust in these key person should influence the perception on stem cell technology. However, the result was shown there was no statistically significantly different in stem cell technology perception among different level of trust in this group. This mean the trust in this close peers did not have any effect on perception.

Effect of interpersonal communication

Interpersonal communication has been rarely introduced into research on public opinion, although, it was reported as an important factor shaping public opinion on stem cell controversy (Liu & Priest, 2009). We examined the interpersonal communication regarding stem cell technology of respondents through the questionnaire. The result showed that within 6 months, most of respondents (N=61, 59.2%) never had a previous discussion regarding stem cell technology with anyone, while some of them (N=33, 32%) had at least 1-2 times discussion about stem cell technology. Few of respondents (N=6, 5.8%) had discussion about stem cell technology around 3-5 times.

Although our respondents have different levels of interpersonal communication regarding stem cell technology with their close peers, but these different levels did not influence their perception on stem cell technology. From statistical analysis result, there was no statistically significantly difference between group of respondents that had different number of communication about stem cell technology. This result is similar to result from similar study done in USA and Canada (Liu & Priest, 2009), the researcher cannot identify the effect of interpersonal communication on stem cell technology perception. Despite of the fact that, the interpersonal communication normally has influence in people's opinions and perceptions (Mazur & Hall, 1990). We decided to evaluate the same factor with previous study, in case the different culture context on a society toward collectivism as Thailand (Hongladarom, 1999) may give the different insight. However, the result was similar to previous study.

Perceived risks & benefits

There was previous study (Liu & Priest, 2009) examined the public perception of benefits associated with stem cell research. However, there was no

assessment of perceived of associated risk examined in the same study. According to another study (Slovic, Finucane, Peters, & MacGregor, 2004), risk and benefit are associated and should be studied in term of their effects on attitude and perception. With this suggestion, we decided to examine both perceived benefits and risks in this study. From total 113 respondents, there were 2 respondents (1.8%) did not perceived stem cell technology as benefit. Most of them perceived benefit of stem cell technology, but the benefit level they perceived was different. Half of respondents (N=56, 49.6%) indicated that stem cell technology is high benefit, 28 respondents (24.8%) and 26 respondents (23%) indicated the benefit at moderate and extreme level, respectively. In term of perceived risk, only 4 respondents (3.5%) consider stem cell technology as no risk at all. The rest of response indicated level of perceived risk as somewhat (N=32, 28.3%), risk (N=58, 51.3%), high risk (N=16, 14.2%), and extreme risk (N=3, 2.7%).

We studied benefits and risks related to stem cell technology in more specific area. The opinion of respondents that the stem cell technology gives the benefit to specific area such as researches, drug discovery and development, medical treatment of uncured diseases, and organ replacement was evaluated. In the same time, the different area with potential risk caused by stem cell technology such as unethical source of stem cells, medical malpractices, medical frauds and scams, health-related or life-threaten issues, conflicts with religious belief, and increasing of medical treatment cost were evaluated.

In term of benefits, the level of respondents who believed that stem cell technology will cause benefit were 74. 3% (N= 83) for research, 75. 2% (N= 85) for drug discovery and development, 83.2% (N=94) for medical treatment of uncured diseases, and 61.1% (N=69) for organ replacement.

In term of risks, the respondents concerned on specific area which may have risk associated with stem cell technology. According to this result, there were 71.7% (N=81) of respondent concerned on unethical source of stem cells, 57.5% (N=65) on medical malpractices, 77.9% (N=88) medical frauds and scams, 39.8% (N=45) on health-related or life-threaten issues, 20.4% (N=23) on conflicts with religious belief, and 34.5% (N=39) on increasing of medical treatment cost.

The effect of perceived risks and benefits on perception on stem cell technology was analyzed. The result from Kruskal-Wallis H test revealed that perceived benefit had statistically significant difference in perception on stem cell technology at $\chi^2(2) = 33.863$, $p = 0.000$. While perceived risk did not have statistically significant different in perception on stem cell technology ($p = 0.193$) We can summarize that the perceived benefits had influence on perception toward stem cell technology while the perceived risks did not have any effect. We cannot compare this effect with other study about stem cell perception as no one did any research in term of perceived risk and benefits.

Conclusions

Considering stem cell technology as an emerging technology with many

unknown, people cannot totally base on their knowledge to justify the acceptance and perception toward it. Previous studies in literature review demonstrated about some factors that evaluated by researchers from different countries have shown the influence on public perception on stem cell technology. This study emphasized the similar factors and measured on different environment and cultural context in emerging developing country like Thailand with interesting findings in term of similarity and opposite with previous reported. In conclusion, we finalized our finding to the new framework as shown in 6. The influence of knowledge and familiarity in our study is contrasted with result from other studies, as public is relied on knowledge than familiarity to set a perception toward the stem cell technology. Media influence still plays an important role in stem cell technology perception in term of media attention and reliability of media. In term of trust on key persons, Thai public perception relies on trust toward some key persons such as scientists (university) or medical doctors than others. The last factor, perceived benefits, is only factor in term of risk and benefit that influence on perception toward stem cell technology.

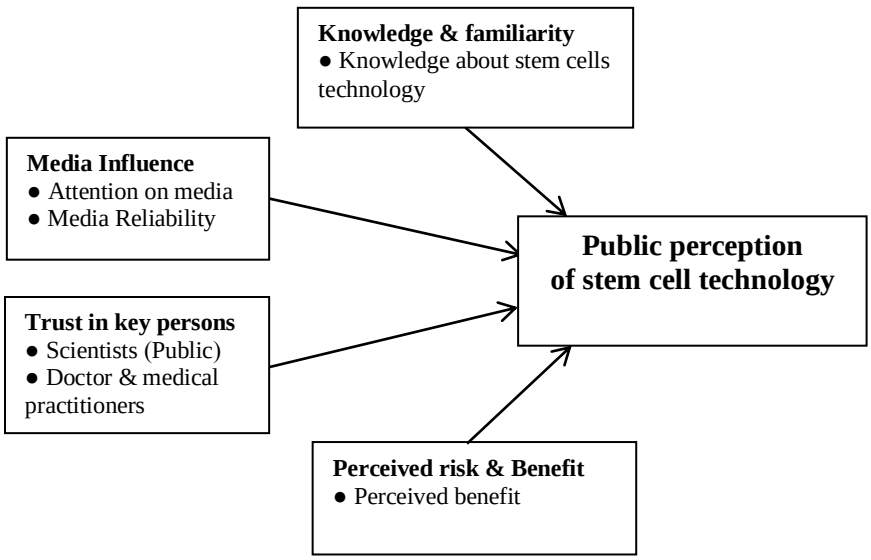

Figure 6 Model of factors influencing public perception towards stem cell technology in Thailand

Managerial implication

Considering that stem cell technology is a new technological concept for Thailand, policy and regulation are still in unclear direction. Our finding can be benefit two target groups; first group is the government segment working on policy and regulation related to stem cell technology as a consideration and preparation of public perception, and second group is private sector that commercializes stem cell related products which can use our finding to shape the right strategy for market preparation and introduction of their products to the market. Our recommendations are:

Firstly, **education** the public and market to have the right knowledge about stem cell technology before introduction of the new policy, regulations, or related product. This will help to prepare the public and market to perceive the benefit and risk of this technology at appropriate level, leads to correct perception and acceptance of stem cell technology.

Secondly, the information related to stem cell technology must be communicated through **trustworthy media channels** to build up the positive perception toward stem cell technology. Due to the fact that the public must pay attention on this information in the level that create effective communication for building the right perception, the communication through media channel must be in the level that bring the attention of society toward this technology.

Thirdly, as the trust in key persons who communicate the knowledge and understanding of the stem cell technology is one of the important factor. **Engagement with the right Key Opinion Leaders (KOLs)** such as experienced and knowledgeable scientists and medical doctors as the key persons who provide the technical knowledge about stem cell technology must be key factors that help build up the correct knowledge in society and leads to right perception on stem cell technology.

Lastly, to make sure that public perceived correct benefits about stem cell technology and lead to positive perception. Communication and information must project the actual benefits of stem cell technology to **create the right level of perceived benefits** on stem cell technology.

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