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The Potential for Menstrually-Derived Stem Cell Banking in the UK

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Abstract

In the UK, there is a growing demand for the NHS to provide cost-effective medical treatment for the ever-increasing, ever-aging population, suffering from chronic non-communicable diseases such as heart disease, diabetes, cancer, and chronic degenerative diseases, such as Alzheimer's disease, Huntington's disease, and multiple sclerosis.

Well-established stem cell treatment includes that for blood and immune system diseases and conditions, such as treating leukaemia with a bone marrow transplant. Skin grafts are grown from stem cells for severe burns cases; and cornea damage (surface of the eye) can be repaired with stem cells. However, stem cell treatment is currently limited by the painful, invasive, and expensive harvesting procedures required.

Stem cells have been found in menstrual blood. Harvesting menstrually-derived stem cells does not require an invasive procedure, can be donated monthly, and can be collected within the donor's home using a menstrual cup. This new source of stem cells could lead to greater accessibility to stem cell therapy and increase the rate of stem cell therapy research.

This paper explores the potential for a menstrually-derived banking system in the UK from a *scientific* and *human factor* standpoint. The scientific community views menstrually-derived stem cells as having potential for application in stem cell therapy. However, the potential for menstrually-derived banking in the UK is driven by the willingness for women to donate their menstrual blood: without the support from women, the entire system is void. The study looks to explore women's initial thoughts, concerns, and inclination to donate, in addition to their first experiences with a menstrual cup, and how guidance and support throughout the process affects this experience. With potential from a *scientific* and *human factor* perspective, the scientific and medical community can anticipate and prepare for the potential for banking menstrually-derived stem cells in the UK.

Note

This paper discusses topics that may be offensive to some readers, frankly discussing the collection and use of menstrual blood, and vaginas. This paper does not set out to offend, but positively contribute to the field of science and medicine for the treatment of a number of diseases and conditions.

Key Words: Menstrually-derived stem cell; Stem cell banking; Stem cells

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1. Introduction

The aim of this paper is to determine the potential for menstrually-derived stem cell banking in the UK from a scientific and human factors standpoint.

Stem cells are cells capable of unlimited self- renewal with the capacity to differentiate into a range of cell types. These cells can therefore be harvested and transplanted into a patient that requires a specific cell type. For example, if a patient is suffering with leukaemia, a stem cell transplant from either the patient or a close tissue match could save the patient's life by replacing deficient white blood cells. Stem cells are typically sourced from human embryos, raising the ethical dilemma related to the destruction of an embryo, but they are also available in adult cells. They can be donated with consent. Whilst adult stem cells are ethically sourced, cost and practicalities are detrimental to their use as a sustainable source of cells. Extraction can cause pain to the patient, and the procedure may take days of recovery. Specialised staff and equipment may be necessary to undergo the harvesting procedure, all at a cost. It is these factors that limit the number of patients that can receive stem cell therapy. The cost of the procedure must be balanced with the benefits and chance of success. Stem cells have been found in menstrual blood. This source of stem cells is pain-free, easy, and cheap to procure, while still sharing the many beneficial characteristic of adult stem cells such as those from bone marrow. Although menstrually-derived stem cells are not effective in curing all conditions, such as failing to completely restore heart function, and not treating all cancer types, the potential for menstrually-derived stem cells to treat a number of diseases and injuries is ever growing. Lung injury, multiple sclerosis, and a number of cancers have been treated by menstrually-derived stem cells, with their medicinal properties transferable to countless other applications. From a scientific standpoint, there is huge potential for the banking of menstrually-derived stem cells in the UK.

Regardless of whether or not women have the ability to donate menstrual blood for stem cell therapy, the perception and experience of donating menstrual blood may have an impact on the true potential of menstrually-derived stem cell banking in the UK. The project aimed to explore women's perception of donating menstrual blood, their experience with the physical donation process using a menstrual cup, and the system to support women during their menstrual blood donation.

The study was undertaken in order to understand the potential for menstrual blood donation from the views of the women who would be donating themselves. General reactions, opinions, and fears of the prospect of donating menstrual blood for use in stem cell therapy were gathered. The use of a menstrual cup was utilised for safe, painless, quick menstrual blood collection. Many women already use a menstrual cup on a regular basis as part of their normal menstrual hygiene routine. In the case for these women, it is understood that the menstrual blood donation process would therefore not require the learning curve and new experience that using a menstrual cup entails. This study was carried out to acquire an understanding of women's experiences when using a menstrual cup for the first time. It also aimed to establish how a range of initial information, instruction, and advice would

affect the positivity and success of a woman's overall first-time experience of a menstrual cup (success being how informed one felt, affecting the confidence of the first time use, and ultimately how comfortable the first series of insertions and removals would therefore be).

An understanding of the potential for menstrually-derived stem cell banking in the UK will provide a clear, more realistic vision of the future of stem cell therapy. Possible problems can be anticipated and the scientific and medical community can prepare for the potential for banking menstrually-derived stem cells.

Literature Review

The literature review looked to scientific and medical papers to explore the potential for banking menstrually-derived stem cells, especially to review whether human factors had been considered. It was discovered that there was minimal literature on this topic.

Stem Cells

Stem cells describe undifferentiated cells with the capacity for unlimited self-renewal under the correct conditions, and the potential to differentiate into a range of specialised cell types; progenitors, precursor and fully committed cells. Although stem cells are typically thought to be isolated from embryos, adult stem cells are also present in most adult tissues (Allickson et al. 2011; Gargett and Masuda 2010; Ryan et al. 2005). These stem cells are from stromal (connective) tissue sources, including bone marrow, umbilical cord, adipose (fat) tissue, molar cells, amniotic fluid, and peripheral blood and are described as mesenchymal stem cells. Source type impacts stem cell potency (the range of cell types a stem cell can differentiate into). Embryonic stem cells are pluripotent, having the capacity to differentiate into all adult cell lineages in the human body. With the capacity to differentiate into several cell lineages, including cartilage, bone, muscle, tendon, ligament, and adipose tissue, mesenchymal stem cells are generally categorised as multipotent (Gargett and Masuda 2010; Kern et al. 2006; Mehrabani et al. 2016; Ryan et al. 2005). However, studies have found bone marrow stem cells can differentiate into neural cells, proving mesenchymal stem cells have the capability to differentiate into lineages "other than the tissue of origin", suggesting these stem cells have pluripotent characteristics (Jiang et al. 2002, p.41). Due to their self-renewal and flexible differentiation potential, stem cells are already used in stem cell therapy, with huge promise for further repair and regeneration of damaged tissue, both allogeneically (host and donor cells are of the same species) and autologously (host and donor are the same individual) (Meng et al. 2007; Zhong et al. 2009).

The development of stem cell therapy is underway, but with the planet's aging population bringing ever more degenerative disease, and the moral imperative to improve success rates for the stem cell therapy that is currently only offered to a small fraction of the population, there is a demand for stem cell therapy to be improved (Daley 2012; Daley and Scadden 2008; Holm 2002; McKay 2000). The author posits that the chosen source for therapeutic stem cells is the key for the development of stem cell therapy. Being pluripotent, embryonic stem cells have a superior potency to mesenchymal stem

cells, but are related to the ethical dilemma of the destruction of an embryo. They can also cause the formation of teretomas (tumours) (Erdö et al. 2003; Amariglio et al. 2009; Hentze et al. 2009). Mesenchymal stem cells are sourced from bone marrow, umbilical cord, adipose tissue, molar cells, amniotic fluid, and peripheral blood. They can be donated with consent, and allow autologous treatment for specific needs, so therefore are not banked. However, they all have retrieval disadvantages. Bone marrow, adipose tissue, molar cells, and peripheral blood-derived stem cells all require procedures with varying degrees of invasiveness and pain. Stem cells from umbilical cord blood and amniotic fluid are not painful to procure, but are only obtained when a woman gives birth, costing the NHS an estimated £70,000 per transplant. Mesenchymal stem cells have more recently been discovered in menstrual blood (Meng et al. 2007), without the disadvantages of pain and high cost, as mentioned with other stem cell sources.

Menstrually-derived Stem Cells

Menstrually-derived stem cells exhibit many characteristics similarly to those of mesenchymal stem cells from other sources (Alcayaga-Miranda et al. 2015a; Gargett and Masuda 2010; Mehrabani et al. 2016). They have been proven to show a strong ability to travel to the injured area (Alcayaga-Miranda et al. 2015a; Lopez-Verrilli et al. 2016; Luz-Crawford et al. 2016; Xiang et al. 2017), with a higher expansion, proliferation and survival rate than bone marrow-derived stem cells (Alcayaga-Miranda et al. 2015a; Lopez-Verrilli et al. 2016; Luz-Crawford et al. 2016; Meng et al. 2007; Nikoo et al. 2012). -n addition they show a higher number of early progenitor colonies - capable of differentiating into white blood cells, red blood cells, and platelets (Alcayaga-Miranda et al. 2015a). Menstrually-derived stem cells have been found to have superior longevity. For example, Allickson et al (2011) discovered they were passaged up to 47 times before dying. Sharing characteristics with other mesenchymal stem cell sources, menstrually-derived stem cells are often described as *multipotent* (Alcayaga-Miranda et al. 2015b; Allickson et al. 2011; Wu et al. 2014). However, menstrually-derived stem cells have the ability to differentiate into all three germ lines (the endoderm (interior stomach lining, gastrointestinal tract, lungs), the mesoderm (muscle, blood, bone), and the ectoderm (skin and nervous system), including lung epithelial cells, and cardiomyocyte (heart muscle), without chromosome mutation (Hida et al. 2008; Meng et al. 2007; Xiang et al. 2017). This reflects the characteristics of *pluripotent* stem cells (Borlongan et al. 2010; Khoury et al. 2014; Meng et al. 2007; Xiang et al. 2017; Zhong et al. 2009). Menstrually-derived stem cells have been successful in treating a wide variety of conditions. These include: acute lung injury (Xiang et al. 2017): type diabetes mellitus (Wu et al. 2014); stroke (Borlongan et al. 2010); multiple sclerosis (Zhong et al. 2009;, some cancers (Alcayaga-Miranda et al. 2016); sepsis (Alcayaga-Miranda et al. 2015b); and critical limb ischemia (Murphy et al. 2008) As well as rebuilding heart tissue (Hida et al. 2008) and beneficially affecting neuronal outgrowth for treatment of neurological diseases (Lopez-Verrilli et al. 2016).

These cells do have their disadvantages: injecting menstrually-derived stem cells to the heart only had a limited effect when restoring function (Hida et al. 2008). In another experiment, the cells were

unsuccessful in reducing the progression of arthritis (Luz-Crawford et al. 2016). Although some cancers were treatable with menstrually-derived stem cells, not all cancers were suppressed by the treatment, including pancreatic cancer (Alcayaga-Miranda et al. 2016). In one experiment, menstrually-derived stem cells were incapable of differentiating into blood cells (Xiang et al. 2017). Specific to menstrually-derived stem cell collection, questions must be answered as to whether age, hormonal status (pre- or post-puberty or pre- or post-menopause), and contraceptive use affects the stem cells in menstrual blood (Khoury et al. 2014). And as with all stem cell therapy, multiple risks including adverse immune responses and tumour growth are associated with menstrually-derived stem cell therapy (Lopez-Verrilli et al. 2016).

Collection of menstrually derived stem cells

Menstrual blood for menstrually-derived stem cell collection is almost exclusively collected using menstrual cups: small medical-grade silicon cups that sit in the vagina to collect, rather than absorb, menstrual blood (Fig. 1). The menstrual blood can then be added to buffering saline and antibiotics, and posted to an NHS laboratory alongside necessary consent forms and sample information, to be processed for culture (Fig. 2). Woman across the UK already use menstrual cups, and as with tampons, they are simple to use, requiring no aid from a medical practitioner to insert or remove. Because of this, the author posits that the menstrual blood donation process would require no trip to a medical practice or designated centre for women to insert or remove their menstrual cup, and therefore could be collected from home.

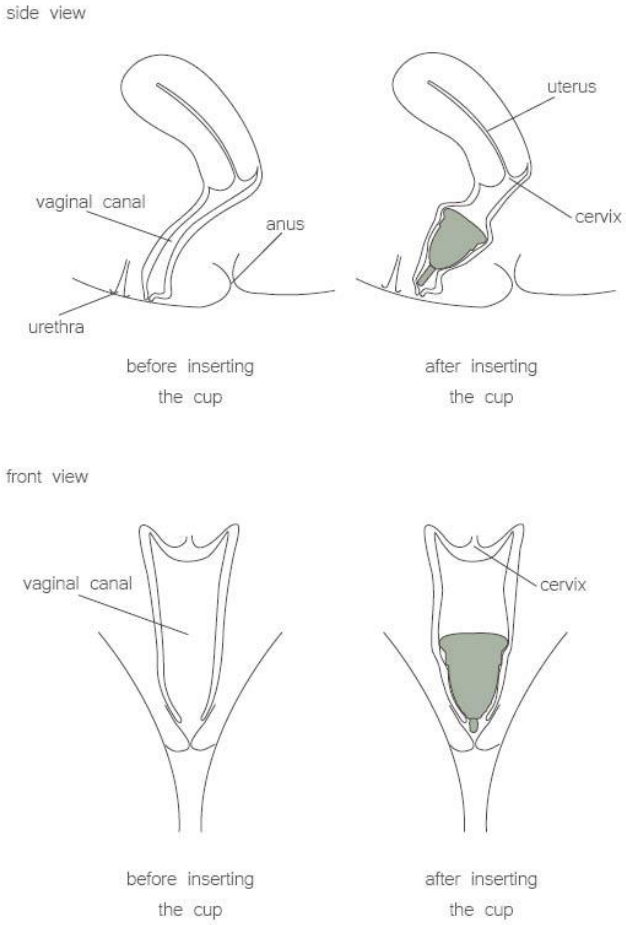

Figure 1: Menstrual blood collection with a menstrual cup

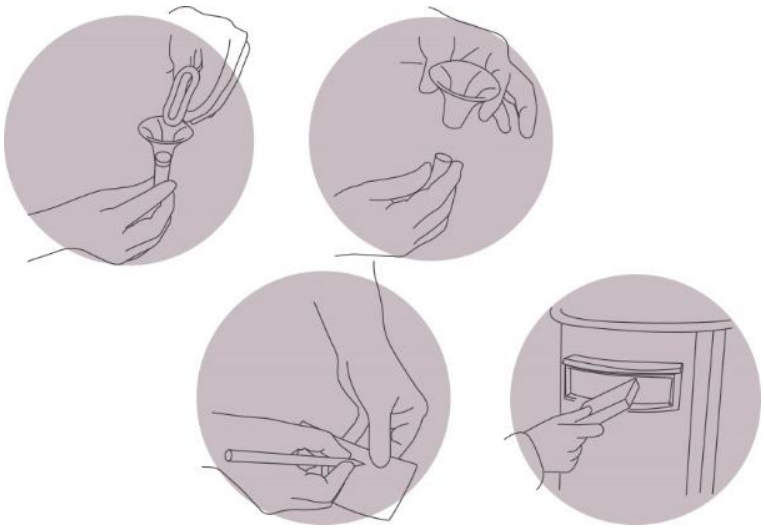

Figure 2: Menstrual blood donation process

Research methodology

To ascertain women's views of using the menstrual cup for the first time, volunteers where sought to try out the cups. They were asked to record their experience in writing. Semi-structured interviews were also held to gather qualitative data regarding the experience and the potential of them donating menstrual blood. The findings from the study were supplemented with six focus groups to receive a better understanding of the perception of menstrual blood and the theme of donating menstrually-derived stem cells from a broader range of women. The study received ethical approval from the Nottingham Trent University School of Architecture, Design, and the Built Environment Ethical Clearance Sub-Committee.

Research activity

After receiving their menstrual cups, the women were asked to provide feedback on the instructions regarding the text, images used, general content, and how easily they could be followed. This was achieved verbally through informal, semi- structured interviews and asking the participants to annotate the instructions provided with single words, phrases, or images. Having participants critique the instructions directly onto the paper would mean there would be absolutely no misinterpretation as to where the instructions worked well or otherwise, and also meant the participants could analyse the instructions in real time, and make notes as their thoughts and ideas were fresh, providing valid data. These instructions could also be easily passed on to the author and analysed with no misconception. Verbal feedback was provided regarding general experiences and emotions while using the cup for the first time in the form of informal, semi- structured interviews. These interviews would be relaxed in order for the participants to feel comfortable while discussing intimate topics, and participant-led. When conversations dropped, the author asked some questions in order to prompt participants (for example: "how did you find seeing the menstrual blood in the cup?", "did you spill any menstrual blood?", and "did you find you could open the menstrual cup easily or did you struggle to open the menstrual cup?"). The conversation was mostly participant-led, as the author understood each participant would have their own thoughts and emotions that the author could not anticipate. The participant would also feel the conversation was more natural-feeling and therefore share their thoughts more openly. Because using a menstrual cup for the first time would generally be a five to seven day experience, or even a two to three month experience, the participants were also encouraged to contact the author with further thoughts, ideas, and feedback in the days, weeks, and even months following the initial first menstrual cup use. This was achieved with personal messaging, as this was convenient, quick, informal, and comfortable method of communication that could be done on the go, or even as the participant inserted or removed the menstrual cup. This would again feel like natural communication, the participants would feel comfortable, and share their opinions and experiences openly, leading to more valid data.

To explore the effect of differing levels of support and instruction on how easy and comfortable the participants found first-time menstrual cup use, varying levels of support and instruction had to be designed (shown in Table 1). One group of participants simply had the standard instructions provided

with the menstrual cup. This was the group with *minimal* instruction and advice. Another group of participants had access to the standard menstrual cup instructions, and a menstrual cup diary: a first-hand, honest record of a woman's first two menstrual cycles using the menstrual cup, with photographs of the used menstrual cups, and anecdotal advice. This was the group with *medial* instruction and advice. The final group of participants had access to the standard menstrual cup instructions, the menstrual cup diary, face-to-face conversation and instruction on using a menstrual cup with another woman confident in using menstrual cups, and finally the opportunity to receive advice in real time during the menstrual cup use from the same woman (this woman is referred to as "the menstrual cup user"). This was the group with *maximal* instruction and advice. How the Participants were split into the support groups is shown in Table 1.

Participant	**Support Group**	**Support**
Participant 1	Medial	Menstrual cup instructions; menstrual cup diary
Participant 2	Maximal	Menstrual cup instructions; menstrual cup diary; face-to-face support from menstrual cup user
Participant 3	Maximal	Menstrual cup instructions; menstrual cup diary; face-to-face support from menstrual cup user
Participant 4	Medial	Menstrual cup instructions; menstrual cup diary
Participant 5	Minimal	Menstrual cup instructions
Participant 6	Minimal	Menstrual cup instructions
Participant 7	Medial	Menstrual cup instructions; menstrual cup diary

Table 1: Participants, Instructions and Support Groups

Focus groups

The findings from the research activity were supplemented with six focus groups to receive a better understanding of the perception of menstrual blood and the theme of donating menstrually-derived stem cells from a broader range of women.

Participants

The participants selected for the study were all friends and family of the author. This was due to the sensitive nature of the study. Having a close relationship to the participants broke down the barriers when talking about menstruation and vaginas on a very personal level. All the participants invited to the study accepted.

Seven female participants from well-educated backgrounds (students/working professionals) were invited to use a menstrual cup for the first time. They were aged between 18 and 23 years of age, and

had all never given birth. Informed consent was received by each participant, after fully understanding the nature of the study. The author kept the participants anonymous. The participants understood their feedback would be kept confidential, with the study abiding to the Data Protection Act (1998). The physical annotated instructions were collected for analysis by the author, and notes were made throughout any interviews with the consent of all the participants. The focus group participants were aged between 18 and 70 years old.

Data Analysis

The data was analysed by the author, and the study findings were produced using abductive reasoning to form the hypothesis that the better informed and supported a woman was throughout the menstrual blood donation process, the better her experience and the more successful the process. Themes including understanding the instructions, discomfort, and mess were anticipated by the author. However, the informal, open quality of the interviews meant that there were themes that the author had not foreseen that were explored in this study, including: approaching other first time users and the education of female anatomy. The raw data from each participant was cross referenced to the others to find links between varying menstrual cup experiences. On all counts, the participants responded calmly, confidently, and naturally, giving the author no reason to assume the participants were not telling the truth.

Results

All the participants had some form of initial understanding of menstrual cups and their use. They all understood the general principles around the menstrual blood collection, opposed to absorption, but not all the participants understood how actual insertion and removal took place. All the participants were happy to try the cup, with a couple of participants expressing hope: "*hoping* [it] *will feel better than using pads*" (Participant 5); "*hopeful it would work*" (Participant 6). All the participants had initial concerns, including the menstrual cup's "*comfort*" (Participant 5), and "*it would leak*" (Participant 6).

Participant	Support Group	Attempts required to comfortably insert/remove menstrual cup	Comments on experience
Participant 2	**Maximal**	**1**	**“easy”, “fully confident”**
Participant 3	Maximal	1	“easy”, “fine”
Participant 1	Medial	2	“minimal discomfort”, “quickly improved”
Participant 4	Medial	3	“comfortable when fully sealed”, “got easier”
Participant 7	Medial	2	“okay”, “uncomfortable at first”
Participant 5	Minimal	1 day of attempts	“scared”, “painful”
Participant 6	Minimal	2 months of attempts	“discomfort”, “leakages”

Table 2: Participants' menstrual cup experience and number of attempts required to comfortably insert/remove menstrual cup

The standard menstrual cup instructions had flaws: Almost all of the participants recognised improvements that could be made to the instructions. The single participant to think otherwise stated: “I read through all of the instructions on the pamphlet first, but I knew what to do anyway from speaking to [the menstrual cup user]” (Participant 2 – Maximal group). All of the participants agreed that the standard instructions, both text and images, were too small. Participant 2 mentioned, “*This* [image of menstrual cup inside vagina] *should be bigger! Cause less panic*”. When trying to learn how to trim the menstrual cup to fit, Participant 4 (Medial Group) stated, “[the information was] *easy to understand but* [the image] *difficult to see how much to leave*”. This statement highlights the importance of clear, large images, leaving nothing for women to guess: when it comes to trimming the menstrual cup stem, making an error can leave the cup difficult and in some cases painful to remove. The content of the instructions was complimented, however, by Participants 1, and 3 to 7.. Highlighting different sections of the leaflet, content was described as “*good*” (Participant 5 – Minimal group)), “*massively useful”* (Participant 4 – Medial group), “*friendly but not too colloquial*” (Participant 1 – Medial group), “*helpful*” (Participant 3 – Maximal group) and “*clear*” (Participant 6 – Minimal group).

When it came to fitting and trimming the menstrual cup, it was met with varying levels of understanding. Participant 1 cut the entire stem off after feeling it protrude out the vagina on first insertion, but feared she “*prematurely snipped the stem*”. It was the correct fit, but Participant 1 is an example of overconfidence and was the only one rushing into the trimming. Participants 2-4, and 6-7

all trimmed their stems without risk of over-trimming, and in some instances "*just doing little bits at a time*" (Participant 7 – Medial group) ensured the participant did not over-trim. Gradual trimming helps women not to trim the stem so short as to make it difficult to remove from the vagina. This is an issue of comfort and confidence: the menstrual cup could still be removed were it to have no stem, but the woman would have to reach further inside her vagina with a thumb and finger to pinch the base of the menstrual cup for retrieval. Having a stem at the ideal length gives the woman confidence she can easily pull at the stem to lower the menstrual cup for retrieval, with the comfort of not having the stem protrude painfully from the vaginal opening:. Primarily participants wanted a comfortable experience, however, the author hypothesises that the cost of the menstrual cup also aids in women being wary of over-trimming. The menstrual cup being worth approximately £20 influenced the women to be more cautious to make the correct trim first time.

There was a range of user experiences, especially regarding comfort and confidence, for the participants when using the cup for the first time. Participant 5 (Minimal group) made these comments, regarding the general experience, "*not comfortable*"; "*scared to take out*"; "*leaked twice*". The discomfort felt and cup leaking suggests the cup was not inserted properly. Feeling discomfort signifies the cup was not sat above the pelvic bone in the vagina, where the vaginal walls cradle the cup. The leaking suggests the cup was not opened correctly inside the vagina; either it remained completely folded, or a crease in the silicon prevented a seal from forming. This is either down to the cup being too big, too flexible, or the participant not understanding how the menstrual cup works. If the latter, it is suggested the participant did not receive adequate instruction and advice before and during menstrual cup use. Following a similar theme, Participant 6 (Minimal group) stated, "*I still haven't fully got used to it, I've only been using it for 2 months* (so 2 weeks actual use) *and I've had a few instances of leakages and discomfort but hopefully that will get better with practice*". Participant 6 may also have not received adequate information and advice in order for her first time using a menstrual cup to go smoothly.

Participant 4 (Medial group) stated "*It took me about three attempts to get myself in the correct position and the correct alignment of the cup with enough force to push it all the way in… the more I practised, the easier i*t [became]". To a similar effect, Participant 1 (Medial group) explained she had a "menstrual cup revelation" with the third use of the menstrual cup; "I'm consistently removing and placing the cup quickly with minimal discomfort". Participant 7 (Medial group) also inserted the menstrual cup correctly on the first few attempts: "*One time I got it in but I could feel it was folded, the second time I thought it was properly in*". These reports show a fairly quick learning time for all of these slightly more confident menstrual cup users. The faster learning time and better general menstrual cup experience suggests that these women had an adequate amount of information and advice available to them before and during their first menstrual cup use.

Participant 3 (Maximal group) had a very comfortable and problem-free first-time menstrual cup use. She explained, "[I] *just popped* [the menstrual cup] *in for the first time and it was absolutely fine, tried taking it out and putting it back in, equally easy! If anything really anticlimactic*". Participant 2 (Maximal

group) also had a very positive first menstrual cup experience. She stated, "*Well that was much easier than I thought it would be!... I knew what to do anyway from speaking to [*the menstrual cup user*]. I was expecting it to be A LOT harder to get in but it just slipped right in… I think my experience was made easier because I know what my vagina feels like and I am comfortable inserting fingers, tampons etc. inside".*

These positive accounts of first-time menstrual cup use suggest that these participants were knowledgeable, having received an abundance of instruction and advice before using a menstrual cup for the first time. Participant 2 also uncovered an unanticipated theme: that of education and understanding female anatomy. Understanding the vagina tilts backwards towards the base of the spine, rather than directly upwards as illustrated in many tampon instructions, is key to successfully inserting a menstrual cup.

Another example of unforeseen themes being highlighted by participants regarding first time menstrual cup use is that of approaching first-time users: *"Would some women be scared off by there being lots of [preparation] beforehand?... You might want to look at how to make* [it*] clear that it's also super easy and nothing to be scared of!... I had in mind that it would sit in the same place as a tampon, but knowing that you are easily able to touch it definitely made me think of it as less of a big deal!"* (Participant 3).

This indicates a balance is possibly required when approaching women with first time menstrual cup use. Where one amount of advice or information would create the perfect preparation for successful first time use, but too much, and the woman is potentially overwhelmed to the point of not going forward with it. Once having tried using a menstrual cup, all of the participants were extremely willing to donate their menstrual blood. It could be suggested that the use of a menstrual cup is the crux of a woman's decision to donate. The balance to inform but not repel future donors, and make the decision to use a menstrual cup for the first time will be further considered in the discussion.

All the participants bar one discussed how the menstrual cup is better for the environment as it produces no landfill waste, and the majority of participants mentioned the potential to save money on menstrual hygiene products, despite the initial cost of the menstrual cup.

The focus groups covered an age range of women between 18 and 70 years old,. The key themes from the focus groups were that the majority of the participants women react positively to menstrually-derived stem cell donation, and women firstly consider themselves when donating. 49/51 participants responded positively to the idea of menstrually-derived stem cell donation, stating they would consider donating their menstrual blood. The two participants who responded negatively to the theme, mentioning the "ick factor", were aged 18 and approximately 60 years old. Understanding that around 96% the focus group accepted the idea of menstrual blood donation, and those that rejected the idea of donation had an age range of 42 years, age and donation acceptance appear to have no correlation. Generally, the older the women, the longer it took for them to understand the idea of menstrually-derived stem cell donation. When it came to discussing donating menstrual blood, once the women generally understood the stem cell treatment process, they were only concerned with how

the process would directly affect them: how does it feel to use the menstrual cup. Approximately 75% of discussion time revolved around this theme. This mirrors the findings in the study and emphasised the importance of information in the menstrually-derived stem cell donation process.

Discussion and recommendations

It can be argued that because the author knew the participants it may present bias in the findings. However, the participants not feeling ashamed or embarrassed allowed for honest responses, which in turn can be argued provided valid data.

The participants had a basic and generally positive preconception of menstrual cups, but none of the participants knew of the existence of stem cells in menstrual blood, or the potential for their use in medicine. This knowledge, with the understanding that menstrual cups would be the tool for menstrually-derived stem cell collection, could be extremely influential in the general acceptance of menstrual cups.

A campaign introducing women to the power of menstrually-derived stem cells and their collection and easy donation with the use of menstrual cups could improve the prospect of the UK having a menstrually-derived stem cell bank on the NHS. For those women who already use menstrual cups regularly, this campaign would encourage the donation of blood that they are already collecting. Women with no menstrual cup experience could be offered a menstrual cup for free, with the expectation that they donate their menstrual blood at least once. The free menstrual cup would give women incentive and liberty to give the menstrual cup a try, with no risk of losing money, at a small cost to the NHS in regard to the huge increase in stem cell donations it might receive.

The amount of information, instruction, advice, and support women receive before and during their first menstrual cup uses affected how assured, pain-free, comfortable, and generally positive the experience was. The minimal, medial, and maximal levels of advice and support offered to the first time menstrual cup users were echoed in their reflection of the experience. Those receiving *minimal* support and advice when using a menstrual cup for the first time experienced the most leaks and discomfort, and took up to two months for the users to get used to the cup with two (Participant 5) or “a few” (Participant 6) cases of leakage. These women relied purely on the written instructions provided by the menstrual cup manufacturer. Those receiving *medial* support and advice when using a menstrual cup for the first time took two to three attempts to correctly insert and remove the menstrual cup without discomfort and leakage. This is a vast improvement on the minimal support group. These women received the standard instructions, as well as a copy of a “menstrual cup diary”: a personal, detailed, and honest account of a woman’s first time menstrual cup use, offering insights and tips, as well as images, presenting the medial support and advice group with realistic expectations of menstrual cup use. Those receiving *maximal* support and advice when using a menstrual cup for the first time were provided with the standard menstrual cup instructions, the “menstrual cup diary”, and finally face-to-face verbal advice and instructions, descriptions, and tips for first time menstrual cup use from a regular menstrual cup user. This group was also offered real-time

help with using the menstrual cups; the users could call or message the menstrual cup user, or have the menstrual cup user physically help with the menstrual cup should they have needed or wanted it. This elevated level of support was again reflected in how quickly and confidently the women inserted and removed the menstrual cup for the first time: the women were able to use the menstrual cup confidently and correctly from first use, with no problem with leakage or discomfort. The better informed, advised, and supported a woman was before and during her first time menstrual cup use, the faster, more successful, and more positive the experience was.

Written instruction given to women preparing to donate menstrual blood should be easy to read. All text and imagery must be large enough for women aged 18-55 to read clearly. Written instructions may not be the most appropriate method to learn how to use a menstrual cup. Participant 2 had one of the most positive and successful first time menstrual cup uses, and she was primarily given first-hand advice and instruction verbally: "*I knew what to do… from speaking to* [the menstrual cup user]". Participant 3 also had one of the most successful first time menstrual cups uses, having access to instructions, the menstrual cup diary and verbal guidance and instruction. She described the experience as "*easy*". These findings suggest that offering future menstrual blood donors listed instructions as only a secondary resource, and offering anecdotal diaries and verbal advice (in the form of conversations, audio messages and videos) as primary resources for using a menstrual cup for the first time would provide the best preparation for the donation experience.

One participant rushed into trimming the menstrual cup stem. Itr would be beneficial if the instruction and advice for using the menstrual cup insists the trimming is to be done slowly and gradually. This would prevent the menstrual cup stem being too short, and therefore slightly more uncomfortable to remove. It is proposed by the author that a choice from a range of menstrual cup sizes, determined following an algorithm for a woman's best fit, would be the most appropriate method for most women choosing to donate to have a comfortably-sized menstrual cup for years to come. All the menstrual cups would have the same length stem, to be trimmed down by each individual to their suiting.

The cost of the menstrual cup may influence how careful someone might be trimming the menstrual cup stem. The author proposes that the whole menstrual blood donation process could be designed for women to care for their menstrual cup, and as an extension, experience a positive and successful donation process. It is already advised that women do not share their menstrual cup with anyone for hygiene and health reasons. Women owning their own menstrual cup, having filled in a survey for their "perfect" menstrual cup fit, may increase the pride and excitement a woman will feel for her cup (and therefore the whole menstrual blood donation process). The menstrual cup packaging, storage items, and any online profile branding could be personalised for each donor, providing a sense of ownership, emotional attachment, and motivation to donate. This would in turn provide a higher readiness for donors and an increase in stem cells banked in the UK.

Participant 2 uncovered an unanticipated theme: that of education and understanding female anatomy. Understanding the vagina tilts backwards towards the base of the spine, rather than directly

upwards as illustrated in many tampon instructions, is key to successfully inserting a menstrual cup. The author therefore hypothesises that further research would support a positive correlation between great female anatomical understanding, and not only the correct placement, but comfortable placement of menstrual cups. The author hypothesises that improving a woman's knowledge of the female anatomy would result in a far superior first time menstrual cup experience.

Participant 3 highlighted that the more information provided to the women, the more likely it would be for them to become overwhelmed or repelled by the process. However, as the findings in this paper show, women who are better prepared for menstrual cup use, found the experience easier and more pleasant. A balance is required, between informing women and not repulsing them. The use of autonomy in this menstrual blood donation process, not only opens up the possibility for women to donate their menstrually-derived stem cells for the use in medicine, it also permits women to decide how they wish to proceed. Offering a wide selection of resources to women (videos on how to insert the menstrual cup; r written accounts of menstrual cup use; or contact with a regular cup user via online messaging), would help make the menstrual blood donation process viable. It is through a range of information and support that the menstrual blood donation process will succeed, and therefore provide the potential for a menstrually-derived stem cell banking system in the UK.

The focus group outcomes indicates that menstrually-derived stem cell banking holds potential for not only younger audiences, but a broad range of women in the UK. Where older women may need more advice, or longer to consider the donation process, there was no evidence to suggest that any age group of women were more or less inclined to donate menstrual blood for stem cell therapy.

Further Research

This small study identified the potential for menstrually-derived stem cell donation and the importance of adequate guidance and support for the women undergoing the donation process. It is clear that a study with a much larger sample size would provide more valid data, with defined correlations being drawn. Sampling women from a broader age range, including women who have given birth, would be useful to understand whether the menstrual cup donation experience is affected by age or life experience, and whether the donation process learning curve changes with age. It is important to recognise that the participants in this study were well-educated young women, either studying at University, or a young professional with a degree. Continuing this research sampling women from a range of backgrounds and education levels will establish whether this proposed donation system is a system that *any* healthy woman of menstruating age, regardless of background and education level, can access. Therefore exploring the true potential for menstrually-derived stem cell banking.

Conclusion

This paper set out to discuss the potential for menstrually-derived stem cell banking in the UK. Science and medical papers point toward the characteristics of the pluripotent stem cells sourced from menstrual blood being suitable for treatment of an ever-growing list of conditions and diseases including diabetes, lung injury, stroke, sepsis, and some cancers. From a scientific standpoint, there

holds potential for menstrually-derived stem cells to be utilised in stem cell banking and therapy, employing the use of menstrual cups for the menstrual blood collection. From a human factors' perspective there is potential for menstrually-derived stem cell banking in the UK. The study found the participants to be happy to donate their menstrual blood for stem cell therapy. Regarding first-time menstrual cup use, the better informed, advised, and supported a woman felt before and during her first time menstrual cup use, the more successful and positive the experience was. Anticipating the problems misinformation and inadequate support causes, the scientific and medical community can prepare for the reality of menstrually-derived stem cell banking in the UK.

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