A curriculum content change increased medical students' knowledge and comfort with transgender medicine

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A CURRICULUM CONTENT CHANGE INCREASED MEDICAL STUDENTS’ KNOWLEDGE AND COMFORT WITH TRANSGENDER MEDICINE

by

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ABSTRACT

Introduction: Transgender individuals experience distress due to the persistent feeling that their gender identity is incongruent with their assigned sex. This distress is associated with depression, a high suicide rate, and increased mortality. The best solution for transgender patients is cross-sex hormone therapy, a treatment that changes the physical sex of the patient to be more congruent with their gender identity. This treatment has been proven to reduce depression and suicide rates, as well as increase overall quality of life. Unfortunately transgender patients face unacceptable barriers to accessing this treatment, due in most part to the lack of willing and knowledgeable transgender care providers. Many physicians share the misconceptions that gender identity is malleable, making transgender identity a psychiatric problem, and that cross-sex hormone therapy may not be effective and carries too great a risk. However, the literature supports the notion that gender identity is a rigid biological phenomenon and that cross-sex hormone therapy is safe and effective. Studies reporting failed attempts to assign female sex to XY patients with disorders of sexual development provide evidence that gender identity is not malleable. Other studies reporting elevated gender identity disorder rates in XX individuals with excess prenatal androgen suggest that gender identity is a biological
phenomenon influenced by hormones during prenatal development. Neuroanatomical studies of transgender cadavers report that some sexually dimorphic areas of the transgender brain are more similar to the opposite sex than the natal sex, suggesting that gender identity is a rigid biological phenomenon originating in the structure of the brain. A review of the side effects and risks associated with cross-sex hormone therapy concluded that treatment is safe provided the physician is familiar with the recommended treatment and monitoring regimens. The lack of transgender care providers is perpetuated by the fact that transgender medicine is not a standard part of the medical school curriculum. Few physicians, therefore, have experience or training in transgender medicine, which is why, to combat this problem, this study has focused on the medical school education system. Previous studies have demonstrated that the addition of transgender medicine to the medical school curriculum increases student comfort and willingness to provide transgender care. Building upon these findings the present study aims to demonstrate that the addition of transgender medicine to the medical school curriculum is an effective means to increase knowledge and change attitudes towards transgender medicine.

Methods: A single lecture on gender identity and transgender medicine was added to the mandatory first-year biochemistry course and the mandatory second-year pathophysiology course at Boston University School of Medicine. An audience response survey was conducted immediately before and after the first-year lecture to assess the change in students opinions regarding of the etiology
of gender identity. An elective online survey consisting of two exam style questions was also sent to the first-year students prior to exposure to the curricular content. The same questions were also added to the first-year biochemistry and second-year pathophysiology exams following exposure to the content. The exam-style questions were designed to assess student knowledge of the rigidity of gender identity and transgender medicine.

**Results:** Following exposure to the curricular content there was an increase in the number of students who believe that the origin of gender identity is in the neuroanatomical structure of the brain (p<0.001). The relative number of correct responses to the exam-style questions significantly improved between the online survey and the first-year exam (p<0.001). On one of the exam questions there was no significant difference between the relative number of correct responses given first-year students the second-year students. On the other exam question the second-year students performed significantly worse (p<0.001).

**Conclusion:** Here we demonstrate that the addition of transgender medicine to a medical school curriculum can increase students’ knowledge and change their attitudes towards transgender medicine. Following the curricular content students were convinced that gender identity is a rigid biological phenomenon and that cross-sex hormone therapy is a medically justified treatment. These findings suggest that a simple curricular content change is an effective means of training knowledgeable physicians who are willing to provide transgender care.
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LIST OF ABBREVIATIONS

AIDS ................................................................. Acquired Immune Deficiency Syndrome
BST ................................................................. Bed Nucleus of the Stria Terminalis
CAH ................................................................. Congenital Adrenal Hyperplasia
CAIS ............................................................... Complete Androgen Insensitivity Syndrome
DSD ................................................................. Disorder of Sexual Development
DSM-IV ........................................................... Diagnostic and Statistical Manual, Fourth Edition
FTM ................................................................. Female-to-Male Transgender Individual
GID ................................................................. Gender Identity Disorder
LGBT ............................................................... Lesbian, Gay, Bisexual, and Transgender
MTF ................................................................. Male-to-Female Transgender Individual
SPSS ............................................................... Statistical Package for the Social Sciences
VIP ................................................................. Vasoactive Intestinal Peptide
INTRODUCTION

The term “transgender” is used to describe someone who has the persistent feeling that his or her gender identity is incongruent with his or her assigned biological sex (Cole, O’Boyle, Emory & Meyer, 1997). While being transgender is not considered a mental disorder in its own right, if the gender-sex incongruence causes distress to the point where it interferes with social or occupational functions, a diagnosis of gender dysphoria may be made (American Psychiatric Association, 2013). Transgender individuals are also highly susceptible to other mental health concerns (e.g. anxiety and mood disorders), often stemming from societal discrimination, prejudice, gender related harassment or violence, and rejection and alienation from family and friends (Lombardi, Wilchins, Priesing, & Malouf, 2002; Williamson, 2010; Hoffman, 2014). There are as many as 700,000 transgender individuals living in the United States (Gates, 2011), an estimated 2/3rds of whom suffer from depression and 1/3rd of whom will attempt suicide during their lifetime (Clements-Nolle, Marx, & Katz, 2006). Fortunately for these individuals, an effective therapy has been developed for their mental health concerns and general wellbeing, “transitioning” (Murad, Elamin, Garcia, Mullan, Murad, Erin, & Montori, 2010). Transitioning is the process of altering one’s social, legal and physical characteristics to make one’s external gender expression match one’s internal gender identity (Hembree, Cohen-Kettenis, Delemarr-van de Waal, Gooren, Meyer, Spack, Tangpricha, &
Montori, 2009). Healthcare professionals assist with the physical aspect of the transitioning process through the means of cross-sex hormone therapy and sometimes genital sex reassignment surgery (Hembree et al., 2009). The greatest barrier to obtaining this treatment is a lack of access to care due to the fact that few physicians are both willing and knowledgeable enough to provide safe quality care (Safer & Tangpricha, 2008). Furthermore, many physicians share the misconception that gender identity is a malleable social construct and can therefore be reversed through cognitive-behavioral therapy and other psychiatric interventions (Safer & Tangpricha, 2008). This misconception may be rooted in the fact that research into the etiology of transgender identity has not identified any genetic, hormonal, gonadal, or genital causes, which only leaves psychological and/or neurological causes (Zhou, Hofman, Gooren, & Swaab, 1995). Additionally, physicians question the legitimacy of hormonal therapy specifically its effectiveness and safety (Safer & Tangpricha, 2008). Despite these objections to cross-sex hormonal therapy a review of the literature provides compelling evidence that gender identity is a rigid biological phenomenon and that cross-sex hormonal therapy is safe and beneficial for transgender patients.

While no set of genes or prenatal events have been identified as specific causes of transgender identity or as specific predispositions towards developing a transgender identity, studies of the gender identities of individuals with disorders of sexual development provide strong evidence that gender identity is at least partially the result of nature as apposed to nurture. One particular study
followed a cohort of 14 XY individuals who were born with cloacal extrophy, a congenital abnormality affecting the pelvis and specifically resulting in severe genital inadequacy (Reiner & Gearhart, 2004). Based on the concept of neonatal sexual neutrality, the idea that gender is a blank slate for both genetic boys and girls at birth and is only dictated by post-natal hormones and experiences, and the limitations in penile reconstructive surgery these XY individuals were legally, socially and surgically assigned female sex within two weeks of birth (Reiner & Gearhart, 2004). This idea that a person who appears physically female and is raised as such, with no knowledge of their genetics or circumstances of birth will naturally assume a female gender identity was the driving force behind what was the recommended treatment for patients with disorders of sexual development (Reiner & Gearhart, 2004). However, during follow up visits 4 of the 14 patients independently declared their gender to be male, despite having been told by their parents that they were female, and another 4 patients openly declared their gender to be male after learning of their XY genetics and their surgery (Reiner & Gearhart, 2004). One patient left the study after finding out their XY genetics, and the remaining 5 continued to live as females with no knowledge of their XY genetics (Reiner & Gearhart, 2004). Interestingly, when the psychosocial wellbeing of the remaining 13 participants was evaluated, the 8 participants living as males were better socialized and more comfortable with their own sexuality, giving some credence to the idea of not altering gender identity (Reiner & Gearhart, 2004). The fact that XY individuals, who appear outwardly female and
were raised as females, spontaneously declared themselves male suggests that there is some chromosomal involvement in gender, which is evidence that gender identity is a biological phenomenon, not a social construct. While the rejection of the given gender identity in the Reiner & Gearhart study provides the most direct evidence that gender identity is not malleable, additional studies shed doubt on our ability to externally influence gender identity. A study surveying a group of 72 XY men and women who were born with a DSD on their satisfaction with their gender and their surgical outcome found that while women were on average happier with their surgical outcome over half of these women had experienced gender confusion (Meyer-Bahlburg, Migeon, Berkovitz, Gearhart, Dolezal, & Wisniewski, 2004). These results support the notion that, while you can make someone appear outwardly female, their gender identity will not necessarily follow suit.

The biological nature of the etiology of gender identity is not just apparent in XY individuals. A study involving a number of XX individuals with congenital adrenal hyperplasia (CAH) also supports the notion that gender identity is not simply a social construct (Slijper & Drop, 1998). CAH is a condition affecting an enzyme involved in the production of cortisone in the adrenal glands, which results in the over-production of adrenal androgen, leading to virilization during the development of the female genitalia (Slijper & Drop, 1998). Additionally, the prenatal and postnatal effects of the increased androgen in individuals with CAH have been noted to result in what is described as "more boyish conduct" than the
girls in the general population (Slijper & Drop, 1998). Slijper & Drop examined 18
XX individuals with CAH and an assigned female sex. Of these 18, two XX
individuals met the criteria for a diagnosis of gender identity disorder (GID)
according to the DSM-IV (Slijper & Drop, 1998). While 11% may be a low
number, it is significantly higher than the incidence of GID in the general
population, suggesting that the prenatal exposure to extra androgen does have
an effect on gender identity. However, because 11% is a minority, it is clear that
CAH does not cause transgender identity, but rather predisposes the individual to
developing a transgender identity, suggesting that gender identity in general is
the product of the interplay between nature and nurture. Slijper & Drop also
looked at 14 XY individuals with complete androgen insensitivity syndrome
(CAIS). CAIS is a congenital condition that results in the development of female
external genitalia and testes in the abdominal or inguinal body cavities
(Deshpande, Chaudhari, & Sharma, 2010). CAIS is caused by a mutation in the
gene that codes for the cellular androgen receptor, resulting in individuals with
who are completely unaffected by androgen (Deshpande et al., 2010). Individuals
are still sensitive to feminizing hormones, however, and often develop female
secondary sex characteristics (Deshpande et al., 2010). Additionally the mutation
in the androgen receptor does not affect anti-Mullerian factor; as a result,
individuals with CAIS do not develop a uterus or fallopian tubes (Deshpande et
al., 2010). Because of the physical outward appearance of CAIS individuals all
18 participants in the Slijper & Drop study were assigned female sex at birth
(Slijper & Drop, 1998). These participants were tested for GID, but none of them qualified for a diagnosis (Slijper & Drop, 1998). The fact that androgen sensitive XY individuals with cloacal extrophy rejected the female-sex assignment, but XY individuals with CAIS did not, suggests that hormones are a key influence in the development of gender. However, the absence of reported gender identity changes in patients who undergo hormone replacement therapy is evidence that postnatal hormones do not have a significant effect on gender identity. Therefore, gender identity is established during prenatal development, and remains rigid as development continues.

While studies of gender identity in patients with disorders of sexual development give us insight into the biological nature of gender identity in general, studies of the brains of transgender cadavers provide the most direct evidence that a transgender identity is also a biological phenomenon. Zhou et al. looked at the bed nucleus of the stria terminalis (BST) of the hypothalamus in heterosexual men, homosexual men, heterosexual women, and male-to-female transgender individuals (MTF). In rodents the BST plays a key role in determining male or female sexual behavior and contains a large number of estrogen and androgen receptors (Zhou et al., 1995). Additionally the size of the BST is sexually dimorphic in rodents (Zhou et al., 1995). While there is no way to determine the gender identity of a rodent, it is likely, given the BST’s dimorphic structure and functions, that the BST has some role in gender identity (Zhou et al., 1995). Using a non-specific vasoactive intestinal peptide (VIP) stain Zhou et
al. measured the size of the BST in cadavers. The results, which are illustrated in Figure 1 and Figure 2, show that men have a significantly larger BST than women; that there is no significant size difference between heterosexual men and homosexual men; and, most relevantly, that MTFs have a significantly smaller BST than both heterosexual and homosexual men and do not significantly differ from heterosexual women (Zhou et al., 1995). In other words the transgender woman’s brain is more similar to a female brain than a male brain. While the specific cause of this difference has not been identified a number of controls were included in the study to assess the effects of hormones on BST size. Three of the MTFs in the study had been off estrogen for between 3 and 15 months prior to death, two of the MTFs had not taken anti-androgen for 2 and 10 years prior to death, and one MTF had not had an orchiectomy, yet none of these MTFs had a significantly different BST size when compared to the other MTFs in the study, suggesting that neither cross-sex hormone therapy nor orchiectomy were significant influences on BST size (Zhou et al., 1995). Additionally a man with an estrogen secreting tumor, a natural model for estrogen supplements, two men with orchiectomies due to cancer, natural models for anti-androgen medication, and two post-menopausal women, natural models for cessation of estrogen supplement, all had BST sizes similar to that of their respective sexes, suggesting that changes in hormone levels have no effect on the size of the BST (Zhou et al., 1995). The fact that hormones appear to have no effect on the apparent female structure of the BST in MTFs and that no specific genes have
been associated with transgender suggests that this difference from the typical XY brain is the result of prenatal neural development, and therefore would not respond to psychiatric therapy. These findings suggest that transgender identity is hard-wired into the structure of the brain, which is why transgender and gender identity in general are rigid biological phenomena.
Figure 1: The Bed Nucleus of the Stria Terminalis of Four Individuals. A non-specific VIP stained cross section of BST in a heterosexual man (a), a heterosexual woman (b), a homosexual man (c), and a MTF (d) is shown. The BST size difference between heterosexual and homosexual men and cisgender and transgender women is illustrated here. The crossbar in the lower right represents 0.5 mm. (Figure take from Zhou et al., 1995)
Figure 2: Relative Sizes of the Bed Nucleus of the Stria Terminalis in Heterosexual and Homosexual Men, Women, and MTFs. This is a graphical representation of the mean size of the BST in four groups: ‘M’ represents the heterosexual male group, ‘HM’ represents the homosexual male group, ‘F’ represents the heterosexual female group, and ‘TM’ represents the MTF group. There is no significant difference in size between the M and HM groups or the F and TM groups. There is a significant difference between the female group and both male groups. There is also a significant difference between the MTF group and both male groups. (Figure taken from Zhou et al., 1995)

Once transgender identity is recognized as a rigid biological phenomenon, cross-sex hormone therapy remains the recommended treatment paradigm, however many physicians question its efficacy and safety (Safer & Tangpricha, 2008). With regards to the efficacy of cross-sex hormone therapy, a review of the literature between 1966 to early 2008 comprising 1093 MTFs and 801 FTMs
who had received cross-sex hormone therapy found that 80% of individuals reported improvements with gender dysphoria (Murad et al., 2010). Additionally 78% of individuals reported improvement with other mental health concerns, and suicide rates decreased significantly, yet still remaining higher than the general population (Murad et al., 2010). Finally 80% of people reported more stable relationships, better adjustment, more overall happiness, and an improved quality of life following cross-sex hormone therapy (Murad et al., 2010).

The safety of cross-sex hormone therapy is affirmed by the literature provided that care is obtained from a physician trained in the supervision of the treatment and the risks involved (Weinand & Safer, 2015). As with any treatment there are some risks of side effects, which must be monitored, but the risks are relatively minor. There has been some association of cross-sex hormone therapy with venous thrombosis in MTF patients (Weinand & Safer, 2015). However, the reported incidence of thrombosis in MTFs is only between 1-8%, and that data is confounded by patients who were treated with the thrombogenic estrogen supplement ethinyl oestadiol, which is no longer used in the current treatment regimen (Weinand & Safer, 2015). One study has even reported a decrease in thromboembolism and other cardiovascular issues with the use of transdermal 17ß estradiol, despite the fact that several of the patients in the study had hypercoaguable gene deficiencies, predisposing them to thromboembolism (Ott, Kaufmann, Bentz, Huber, & Tempfer, 2010). Regardless of whether or not there is an increased risk of embolism, the current treatment regimen recommends
minimizing other risk factors and monitoring for thromboembolism (Hembree et al., 2009). Another potential side effect listed in the treatment guidelines is an increased risk of cancer, a concern that the literature does not support (Hembree et al., 2009; Weinand & Safer, 2015). In terms of breast cancer, there does not appear to be any additional risk in trans-men or trans-women compared to men and women, respectively (Wierckx, Mueller, Weyers, van Caenegem, Roef, Heylens, & T’sjoen, 2012). For FTMs testosterone appears to cause atrophy of the endometrial tissue and the cervical epithelium, reducing risk of cancer (Weinand & Safer, 2015) Additionally, one study reported no increase in genes related to endometrial proliferation or malignancy among FTMs (Gardner & Safer, 2013). There are reports of prostate cancer among MTFs amounting to an incidence of 0.04%, compared to the national incidence of 15% among all males (Weinand & Safer, 2015; National Cancer Institute, 2011). Although there is no additional risk of cancer in transgender patients an important consideration for a physician treating a transgender patient, whether they are providing cross-sex hormone therapy or not, is monitoring for cancers associated with the natal sex, i.e. cervical and prostate (Weinand & Safer, 2015). Although transgender individuals as a group have an increased mortality of 51%, this elevated mortality is caused by the increased suicide, AIDS, and substance abuse rates, not cross-sex hormone therapy, which does not increase mortality (Asscheman, Giltay, Megens, Ronde, Trotsenburg, & Gooren, 2011; Weinand & Safer, 2015). There does appear to be some decrease in insulin sensitivity and elevated fasting
glucose, increasing the risk of type II diabetes (Weinand & Safer, 2015).

However, the treatment regimen recommends monitoring blood glucose levels and, if there are additional diabetic predispositions in the patient, discussing the risks and benefits of treatment (Hembree et al., 2009). Overall cross-sex hormone therapy improves transgender patients’ health, wellbeing, and quality of life with minor risks, which can be ameliorated by following the recommended monitoring guidelines.

Cross-sex hormone therapy is straightforward, clearly beneficial to the patient, and safe when supervised by a trained physician. Unfortunately, the biggest barrier to obtaining this therapy is access to a trained physician (Safer & Pearce, 2013). Due to the general lack of knowledgeable providers some desperate transgender patients even seek alternative means of obtaining treatment, like the Internet or unknowledgeable healthcare providers, which may not be able to provide safe quality care (Safer & Tangpricha, 2008). These disparities are perpetuated by the fact that few medical schools adequately cover transgender medicine in their curricula (Obedin-Maliver, Goldsmith, Stewart, White, Tran, Brenman, Wells, Fetterman, Garcia, & Lunn, 2011). It is because the apparent source of this disparity is lack of experience and education on the subject that research has been focused on developing ways to train knowledgeable physicians who are willing to provide transgender care through changes to the medical school curriculum. In 2013 Safer & Pearce published a study that tested the effects of such a change by adding transgender medicine
content to the endocrinology unit of the mandatory second-year pathophysiology course at Boston University School of Medicine. The curricular content focused on the evidence supporting gender identity as a rigid biological phenomenon, the cross-sex hormone therapy treatment regimens, and the monitoring regimens (Safer & Pearce, 2013). Prior to exposure to the content all of the medical students at the university were invited to take an online survey assessing their discomfort providing hormones to a hypogonadal male, a hypogonadal female, a MTF and a FTM (Safer & Pearce, 2013). Additionally the students were asked if they thought transgender medicine was an appropriate topic for conventional medicine and if they would turn away a transgender patient (Safer & Pearce, 2013). The survey was sent out again following the second-year’s endocrinology unit, and the second year’s answers were compared to the responses given by rest of the medical students at the university (Safer & Pearce, 2013). The results, which are shown in Figure 3, showed that following exposure to the curricular content anticipated discomfort with treating a MTF decreased 63% and anticipated discomfort with treating a FTM decreased 67% (Safer & Pearce, 2013). Additionally the relative number of students who reported that transgender medicine was inappropriate for conventional medicine dropped to 0 and the relative number of students who reported that they would refuse to treat a transgender patient also decreased significantly (Safer & Pearce, 2013). These results demonstrate that a change to curricular content is capable of altering medical professionals willingness to treat transgender patients, but do not
sufficiently demonstrate that students changed their views regarding gender identity or increased their knowledge of transgender medicine following the additional curricular content.
Figure 3. Anticipated Discomfort With Providing Transgender Care. Figure 3A shows a 67% decrease in discomfort treating a FTM patient following exposure to the curricular content. Figure 3B shows a 63% decrease in discomfort treating a MTF patient. (Figure taken from Safer & Pearce, 2013)
Building upon Safer & Pearce's results demonstrating that the addition of transgender medicine content focusing on the biological evidence for a rigid gender identity and the etiology of transgender identity to the medical school curriculum increased student comfort and willingness to treat transgender patients, we aim to demonstrate that such a curricular content change will both increase knowledge and change attitudes towards transgender medicine.
METHODS

Curriculum content was added to the sex-steroid unit of the mandatory first-year biochemistry course and to the endocrinology unit of the mandatory second-year pathophysiology course at the Boston University School of Medicine. The first-year content consisted of a single lecture presenting the evidence for a rigid biological gender identity. The second-year content consisted of a single lecture reviewing the rigidity of gender identity, and covering the treatment regimens and monitoring requirements for cross-sex hormone therapy. The cohort of second-year students had received the first-year content during the previous year. The study consisted of two surveys: an audience response question and two exam-style questions.

Audience Response Survey

Immediately before and after the first-year lecture students were asked what they thought was behind the etiology of gender identity while presented with the slide shown in Figure 4. Each response choice on the slide was explained to the students before they answered. Responses were recorded using a digital clicker system with anonymous clicker identification numbers, allowing the matching of individuals’ answers before and after the lecture. A Pearson Chi-Square test was used to analyze the overall answer choice frequencies of the pre-lecture and post-lecture responses. Additionally, McNemar’s Test was used
to analyze the matched pre-lecture and post-lecture responses for each answer choice. All statistical analysis was conducted with SPSS software.

### Background

Potential factors determining gender identity:

1. Environmental
2. Social Construct
3. Anatomy
4. Hypothalamus
5. Chromosomes
6. Hormones

**Figure 4. Audience Response Slide.** Students were asked what they thought determined gender identity while presented with this slide. Each response was described to the class in the following ways: answer choice ‘1. Environment’ means that gender identity is the result of postnatal experiences and surroundings, ‘2. Social Construct’ means that gender is a learned set of behaviors arbitrarily established by societal conventions, ‘3. Anatomy’ means that gender is determined by primary sexual characteristics, ‘4. Hypothalamus’ means that the origin of gender identity is in the structure of the brain, ‘5. Chromosomes’ means that gender is determined by genetics, and ‘6. Hormones’ means that gender is the result of sex-hormone levels. Answer choice ‘4. Hypothalamus’ was the response indicated by the evidence presented during the lecture.
Exam-Style Survey

Prior to the first-year lecture an elective anonymous online survey was sent to the students using the qualtrics service. The online survey consisted of two exam-style questions, which are described in Figure 5 and Figure 6, aimed at assessing knowledge of the etiology and the rigidity of gender identity. The online survey questions were then added to the first-year biochemistry exam given following the sex-steroid unit. The online survey questions were also incorporated in the second-year pathophysiology exam given following the endocrinology unit. The professors scored individual exams and only the overall performance on the two questions was collected for research purposes to protect the anonymity of students. Answer choice frequencies from the online survey and both exams were analyzed using Pearson’s Chi Square tests. All statistical analysis was conducted using SPSS software.
The first exam-style question was designed to assess how effective the curricular content was at imparting information regarding the etiology of gender identity. Specifically, this question required students to understand the evidence supporting the biological nature of transgender identity. The following is a description of what each answer choice suggested:

A. Transgender identity is associated with childhood psychological trauma.

B. Transgender identity is associated with an underlying hormone condition.

C. **Transgender identity is associated with neuroanatomical microstructure that is more similar to the opposite sex.**

D. Gender identity is a social construct.

E. Gender identity is tied to sexuality.

**Figure 5. Description of the First Exam Style Question.** This is a description of the goals, prompts, and answer choices for one of the exam-style questions that was presented on the online survey, the biochemistry exam, and the pathophysiology exam. For the purpose of reporting, this question shall be referred to as the ‘the first exam question’; however, this question did not necessarily appear before the second exam question on the survey or exams. The correct answer is highlighted in bold here, but was not so on the survey or the exams.
The second exam-style question assessed students' knowledge of gender identity, transgender identity, and cross-sex hormone therapy. Additionally, it assessed whether or not students viewed cross-sex hormone therapy as a valid treatment. In this question students were presented with a transgender individual with additional mental health concerns and asked to select a treatment. The following is a description of what each answer choice suggested:

A. Transgender identity is the result of psychological stress and should be treated through psychiatric intervention.

B. Transgender identity is a set of maladaptive behaviors and should be treated through psychiatric intervention.

C. Only the additional mental health concerns should be treated.

D. Transgender identity is caused by an underlying hormonal imbalance that can be corrected.

E. Cross-sex hormone therapy is an appropriate treatment for transgender patients.

**Figure 6. Description of the Second Exam Style Question.** This is a description of the goals, prompts, and answer choices for one of the exam-style questions that was presented on the online survey, the biochemistry exam, and the pathophysiology exam. For the purpose of reporting, this question shall be referred to as the ‘the second exam question’; however, this question did not necessarily appear after the first exam question on the survey or exams. The correct answer is highlighted in bold here, but was not so on the survey or the exams.
RESULTS

A total of 43 first-year students responded to the audience response survey. Of this sample 39 students answered both the pre-lecture and post-lecture question. Two students only answered the question before the lecture and two students only answered the question after the lecture. There were therefore 41 students who answered the pre-lecture question and 41 students who answered the post-lecture question.

Prior to exposure to the curricular content 46% (n=41) of students believed that varying hormone levels in the body is what determines gender. A chi-square test determined that this response was chosen by a significant number of students, $X^2 (5, N=41) = 27.93, p<0.001$. Following the first-year lecture 80% of students selected the response ‘Hypothalamus’, reflecting that the origin of gender identity is in the structure of the brain. A chi-square test determined that this response was chosen by a significant number of students, $X^2 (5, N=41) = 123.9, p<0.001$. In order to determine if the students responses after exposure to the curricular content were significantly different from their original responses a chi square test was performed, which showed that the difference was significant, $X^2 (5, N=82) = 36.69, p<0.001$. Figure 7 illustrates the relative frequency with which the first-year students chose each response option before and after the lecture. Table 1 summarizes the individually matched responses that students gave pre-lecture and post-lecture. McNemar’s test was performed on each of the
response options to determine if a significant number of students changed their answer to or from a given response. The results of this test found that following exposure to the curricular content a significant number of students changed their answer from ‘Hormones’, $X^2 (1, N=39) = 5.50$, $p=0.019$, and that a significant number of students changed their answer to ‘Hypothalamus’, $X^2 (1, N=39) = 27.04$, $p<0.001$.

Figure 7. Responses to the Audience Response Question. These are the relative frequencies with which each response to the audience response question, which is shown in Figure 4, was selected immediately prior to the first-year lecture ($N=41$) and immediately following the first-year lecture ($N=41$).
Table 1. Summary of Pre-Lecture and Post-Lecture Audience Response Data. These are the matched responses to the audience response question, which is shown in Figure 4. The rows represent individual students responses before the lecture and the columns represent matched responses from those students after the lecture. Empty cells represent zero respondents. A significant number of students changed their answer from hormones (p=0.019) and to hypothalamus (p<0.001) following the lecture.

<table>
<thead>
<tr>
<th>Pre-Lecture Response</th>
<th>Environment</th>
<th>Social Construct</th>
<th>Anatomy</th>
<th>Hypothalamus</th>
<th>Chromosomes</th>
<th>Hormones</th>
<th>No Answer</th>
</tr>
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<td></td>
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<td>1</td>
<td>1</td>
<td></td>
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<tr>
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<td></td>
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<td></td>
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</tr>
<tr>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
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<td></td>
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<td>16</td>
<td>1</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

A total of 56 first-year students responded the online survey prior to exposure to the curricular content. A total of 121 first-year students took the exam following the sex-steroid unit of the biochemistry course. A total of 189 students took the exam following the endocrinology unit of the pathophysiology course. The pathophysiology course was made up of approximately 80% second-year medical students and 20% physician assistant students. Because the online survey and exam were anonymous it was not possible to determine
how individual students responded to the exam-style questions before and after the lecture. However, the exam was mandatory and therefore all of the respondents to the online survey should have taken the exam.

For the purposes of reporting results the exam-style questions shall be referred to as the ‘first exam question’ and the ‘second exam question’ in reference to Figure 5 and Figure 6, respectively. Prior to exposure to the curricular content 62.50% (n=56) of online survey respondents correctly answered the first exam question. A chi-squared test determined that this percentage was a significant, \( X^2 (1, N=56) = 64.54, p<0.001 \). During the first-year biochemistry exam 92.56% (n=121) of students chose the correct response to the first exam question, which was also significant as determined by a chi square test, \( X^2 (1, N=121) = 398.2, p<0.001 \). A chi-square test was performed to determine if the increase in the relative number of students who chose the correct response to the first exam question following exposure to the curricular content was significant. This difference between the pre-exposure and post-exposure correct responses to the first exam question was significant, \( X^2 (1, N=177) = 24.58, p<0.001 \).

On the second exam question, 19.64% (n=56) of students who took the online survey chose the correct response, which was determined to be an insignificant percentage by a chi-square test, \( X^2 (1, N=56) = 0.004, p=0.95 \). The most popular incorrect answer, answer choice C, was chosen by 43% (N=56) of students, a significant number as determined by a chi-square test, \( X^2 (1, N=56) = \)
18.29, p<0.001. During the biochemistry exam 49.59% of first-year students chose the correct response to the second exam question, which was determined to be a significant portion of the respondents by a chi-square test, $X^2 (1, N=121) = 66.20, p<0.001$. The most common incorrect answer on the biochemistry exam was answer choice C, which was chosen by 32% (N=121) of students, a significant number as determined by a chi-square test, $X^2 (1, N=56) = 11.31, p<0.001$. A chi-square test was performed to determine if the increase in the relative number of correct answers to the second exam question on the biochemistry exam, compared to the correct answers on the online survey, was significant. The difference between the relative number of correct responses to the second exam question on the online survey and biochemistry exam was significant, $X^2 (1, N=177) = 14.28, p<0.001$.

On the pathophysiology exam 62.43% (n=189) of students chose the correct answer to the first exam question, which was determined to be a significant percentage by a chi square test, $X^2 (1, N=189) = 212.7, p<0.001$. For the second exam question, 55.03% (n=189) of students chose the correct answer, which was also determined to be significant by a chi square test, $X^2 (1, N=189) = 144.9, p<0.001$. Figure 8 illustrates the relative frequency with which each answer choice was chosen for the first exam question. The most popular incorrect answer to the first exam question given by the second-year students was answer choice D, which was chosen by 28% (N=189) of the students. A chi square test determined that this incorrect answer represented a significant
portion of the student answers, $X^2 (1, N=189) = 6.667, p<0.01$. Figure 9 illustrates the relative frequency with which each answer choice was chosen for the second exam question. The most popular incorrect response given by the second-year students to the second exam question was answer choice C, which was chosen by 30% (N=189) of students, a significant number as determined by a chi-square test, $X^2 (1, N=189) = 10.95, p<0.001$. A chi-square test was performed to determine if there was a significant difference between the percent of first-year students who correctly answered the first exam question on the biochemistry exam exam and students who correctly answered the first exam question on the pathophysiology exam. The percentage of first-year students who correctly answered the first exam question was significantly higher than the pathophysiology students, $X^2 (1, N=310) = 34.97, p<0.001$. This same test was repeated for the second exam question, and there was no significant difference between the first-year students’ and the pathophysiology students’ correct response rates, $X^2 (1, N=310) = 0.8761, p=0.349$. 
Figure 8. Responses to the First Exam Question. These are relative frequencies with which each answer choice was selected on the online survey (n=56), the first-year biochemistry exam (n=121) and the second-year pathophysiology exam (n=189) for the first exam question, which is described in Figure 5.
Figure 9. Responses to the Second Exam Question. These are the relative frequencies with which each answer choice was selected on the pre-lecture online survey (n=56), the first-year biochemistry exam (n=121) and the second-years pathophysiology exam (n=189) for the second exam question, which is described in Figure 6.
DISCUSSION

This study demonstrated that the addition of a transgender medicine unit, which is built upon the biological evidence for a rigid gender identity, to the medical school curriculum is effective in both educating students about transgender medicine and convincing them that gender identity is a rigid biological phenomenon and that cross-sex hormone therapy is medically justified. Transgender patients face unnecessary barriers to healthcare due in most part to a lack of access to knowledgeable physicians. Because few medical schools cover transgender medicine in the curriculum many physicians are ill informed, and some still believe that gender identity is reversible and that cross-sex hormone therapy carries too much risk. These unsupported concerns reduce physicians' willingness to treat transgender patients, and contributes to healthcare disparities. The curricular content change in this study aims to ameliorate this problem by making the evidence-based argument that cross-sex hormone therapy is the best available treatment for transgender patients, with the goal of convincing healthcare providers. This is the first study that demonstrates that healthcare providers transgender medical knowledge and attitudes can be improved with a simple educational intervention.

We hypothesized that the additional curricular content would change students' attitudes toward transgender medicine. The results of the audience response survey demonstrated that prior to the lecture students did not have a clear idea of the origin of gender identity. Almost half of first-year students who
responded to the audience response survey shared the misconception that varying hormone levels determine gender identity. If that were true, then transgender identity would be symptomatic of an underlying hormonal condition, which it is not. Following exposure to the curricular content, however, a significant number of students changed their opinion to reflect that gender identity is rooted in the structure of the brain. Overall the results suggest that the curricular content was effective in convincing the students that gender identity is a rigid biological phenomenon. Additionally the fact that a significant number of students changed their answer from “Hormones”, suggests that the content was effective in eliminating the misconception that transgender identity is the result of an underlying hormonal condition. Despite the misconception held by many physicians that gender identity is a malleable social construct, the number of first-year medical students who thought that gender identity is a social construct was not significant. The absence of this misconception, suggests that the idea of neonatal sexual neutrality and a reversible gender identity may be instilled during medical training, since it was not a common preconceived notion going into medical school. Therefore, it would reason that changing medical training to include the evidence for rigid gender identity and the safety and effectiveness of cross-sex hormone therapy would be an effective means of combating the misconception that gender identity is a social construct.

The first exam question, described in Figure 5, primarily tested students’ knowledge of the evidence supporting a biological origin of transgender identity,
specifically the gender dimorphic neuroanatomical evidence. Even though the majority of the online survey respondents correctly answered this question prior to the curricular content, the number of first-year students who selected the correct answer choice significantly increased following exposure to the curricular content, suggesting that the content was effective in increasing the student’s knowledge and understanding of gender identity and transgender identity. Because the online survey was elective it is possible that the interested respondents were informed on the topic, which could explain why over half of them correctly responded prior to the lecture. On the pathophysiology exam given to the second-year students the majority of students selected the correct response to the first-exam question; however, there was a 31% decrease in correct responses compared to the first-year students. The dip in correct responses could reflect the durability the information has after being taught. There was a full year between when the first-year lecture was given to the cohort of second-year students in this study and pathophysiology exam. Additionally, 28% of pathophysiology students incorrectly chose the response reflecting that gender identity is a social construct and the product of postnatal experiences. This result, in conjunction with the fact that no significant number of first-year students suggested that gender identity was a social construct, supports the notion that the ‘gender identity is a social construct’ misconception is perpetuated in medical training. It is possible that some students were exposed to this misconception between the first-year and second-year lectures. Another possible
explanation is that the minority of physician assistant students, none of whom received the first-year lecture, may have made up a large portion of the incorrect responses. Regardless of why a significant number of pathophysiology students thought gender identity was a social construct, they were still only a minority of the class. The fact that the majority of students responded correctly suggests that the curricular content is effective at increasing knowledge, and that the majority of students retain the information over time.

Once gender identity is recognized as a rigid biological phenomenon psychiatric therapies aimed at altering gender identity are not justifiable, leaving cross-sex hormone therapy as the best treatment option. The second exam question was aimed at testing knowledge, but also assessed whether or not students recognized that cross-sex hormone therapy was a viable treatment option. In the second exam question, described in Figure 6, students were presented with a patient suffering from gender dysphoria and asked to recommend a treatment for the patient’s chronic symptoms. Prior to exposure to the curricular content the majority of online survey respondents selected answer choice C, reflecting a conservative psychiatric treatment focused on the patient’s associated mental health concerns, not their gender dysphoria. Following the curricular content, however, the majority of both the first-year and the second-year students chose the correct answer, suggesting that they thought cross-sex hormone therapy was the best treatment option. The fact that the majority of students who have been exposed to the curricular content were able to correctly
answer the question suggests that the content is effective in increasing their knowledge of gender identity and convincing them of the legitimacy of cross-sex hormone therapy. Despite the fact that the first-year content was primarily focused on gender identity, and not cross-sex hormone therapy treatment regimens and monitoring regimens, which were covered in the second-year content, there was no significant difference between how the first-year and second-year students responded, supporting the notion that accepting the concept of a rigid biological gender identity increases acceptance of the legitimacy of cross-sex hormone therapy.

Interestingly, a significant number, representing less than one-third of both the first-year and second-year students incorrectly chose the answer choice C on the second exam question, which reflected that they thought that a psychiatric approach aimed at treating the associated mental health concerns was the best treatment option. These results could suggest that a minority of students remain unconvinced by the evidence presented that cross-sex hormone therapy is legitimate, and would rather manage the symptoms of depression and anxiety associated with gender dysphoria, than the gender dysphoria itself. Another possible explanation is that this question was simply more difficult than the first exam question. To find the correct answer one must recognize that gender identity is rigid and that other mental health concerns are ameliorated by treatment of body dysmorphia in order to come to the conclusion that cross-sex hormone therapy would be the best treatment, as apposed to the first exam.
question which simply required recall of the association between transgender and gender dimorphic neuroanatomical structures.

A major limitation to this study is that it was conducted at one medical school. Boston University is located in a particularly socially liberal and LGBT friendly part of the nation. It is possible that the socio-political climate influenced the results. A liberal student body may be more receptive to such a controversial topic than a more conservative group. However, the information presented in the curriculum relies heavily on biological evidence, which should circumvent some of the effects of political opinion. Additionally, young medical students may be less likely to scrutinize what they are taught and more likely to accept the conclusions presented by a professor. It is possible that if the same information was presented to groups of medical residents, newly practicing physicians, and long practicing physicians that not all groups would be as receptive to the information. Another limitation was the low number of online survey respondents, which may represent a more interested group that may not necessarily be completely representative of the entire class. The low number of lecture attendees compared to the number of test-takers is another limitation. There were 43 students who responded to the first-year audience response questions, but 121 students who took the exam. It is possible that the remaining 64% students who did not respond or attend lecture were not as convinced regarding the etiology of gender identity. Additionally, only 70 to 100 students attended the pathophysiology lecture, but 189 students took the exam. While both the first-
year and second-year lectures were recorded and posted online, there is no way to know if the absent students actually watched the lecture prior to the exam, which may have skewed the results.

The study’s limitations do, however, provide new avenues for research. Due to the nature of the curricular content it would be possible to add the exact same material to medical school curricula across the country to determine if geo-political climates do indeed have an influence on how effective the curricular content is in creating informed physicians who are willing to treat transgender patients. Additionally the content could be adapted to be presented to medical residents and long practicing physicians to assess if the content can universally inform and convince healthcare providers of the merits of treating transgender patients with hormones. Further research should be done to assess why this curricular content is effective. Isolating the most convincing parts of the argument would assist in the adaptation of the curriculum to other medical professionals. Another possible follow up to this research would be investigating the misconception that gender identity is a social construct, and specifically why only the pathophysiology students had a significant number of people who adhered to the misconception.

Overall the curricular content change increased medical students’ knowledge of transgender medicine and made them more receptive to cross-sex hormone therapy as a legitimate, effective, and safe treatment option for transgender patients. In 2013 Safer & Pearce demonstrated that the same
curricular content change presented in this study increased medical students’ comfort with treating transgender patients, and reduced students’ anticipated apprehension towards providing cross-sex hormone therapy. Together our findings suggest that this curricular content change is effective in training physicians who are knowledgeable and willing to provide care for transgender patients, and that making transgender medicine a part of the standard medical school curriculum could provide a possible means for addressing and eliminating the barriers to safe transgender healthcare. However, focusing solely on medical school education can only bring about change slowly, as the ratio of current physicians to current medical students is large. In order to completely eliminate the difficulties accessing care brought about by the lack of knowledgeable and willing transgender care providers, the curriculum content must be adapted to reach a multitude of healthcare providers with varying years of experience practicing medicine.
REFERENCES


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Education

Boston University School of Medicine
Master of Science in Medical Sciences
Graduation: Expected May 2015

Boston University, Boston, MA 02215
Bachelor of Arts in Biology and Psychology Cum Laude
Graduation: May 2012

Trinity Preparatory School, Winter Park, FL 32792
Graduation: June 2008

Employment

Graduate Resident Assistant Boston University.
Employer: Chester Li cli0331@bu.edu (617) 353-3834
August 2014 - Present
610 Beacon Street. Boston, MA. 02215.
Responsibilities
• Provided orientation, training, supervision and regular evaluation of a
  staff of 20 Resident Assistants.
• Planned and implemented educational, cultural and recreational
  programming.
• Performed administrative duties.
• Responded to crisis or emergency situations in the residential campus.
  Coordinated with team of 19 during weekly meetings.

Research Assistant in Computational Neurophysiology at Boston University.
Principal Investigator: Prof. Michael Hasselmo PhD. hasselmo@bu.edu
(617) 353-1397
August 2010 - September 2012
2 Cummington St. Boston, MA. 02215.
Responsibilities
• Study memory systems using behavioral and neurophysiological
  techniques in conjunction with computational modeling.
• Independently design and carry out team projects for the principal investigator.
• Mouse and rat handling/training, mouse and rat injections, hyperdrive construction, stereotactic surgeries, in-vivo recordings, fix-perfusions, brain sectioning, and brain immunohistochemistry staining.
• Data analysis of in-vivo recordings and EEG waves using Offline Sorter, Neuralynx software, Plexon software, MATLAB, and SPSS.
• Record keeping using MS Office applications

Resident Assistant Boston University.
Employer: Brandon White whiteb18@gmail.com (617) 358-5800
August 2010 - September 2012
33 Harry Agganis Way. Boston, MA. 02215.
Responsibilities
• Mediated conflicts and assessed and responded to the needs of 50 residents.
• Planned and implemented educational, cultural and recreational floor events.
• Performed administrative duties, including acting as an administrative assistant at the front-desk and filing weekly status reports, event trackers, incident reports and maintenance requests.
• Communicated sensitive information and coordinated with emergency services during medical transports, law enforcement, fire incidents.
• Coordinated with team of 19 during weekly meetings.

Volunteer Experience
Rosie’s Place Homeless Shelter Volunteer (2014-Present)
2012 Election Campaign Volunteer and Neighborhood Team Leader
Dance Marathon (2011-2012)
EMT Observer/Volunteer at Boston Medical Center (2011)
Give Kids the World (2010-2013)
Homegrown Co-Op (2010-2012)
Volunteer at Massachusetts General Hospital, Boston Massachusetts (2009-Present)
Undergraduate Teaching Assistant at BU for Biology I (2009-2010)
Residence Hall Association (2008-2010)
World Council for Gifted and Talented Volunteer (2005,2008)
Habitat for Humanity Volunteer (2005-2008)
National Association for Gifted Children Conference Volunteer (2006)
Ronald McDonald House Volunteer (2005-2006)
Awards and Honors
Ruth and Martin Levine Scholarship Recipient (2013)
Psi Chi Induction (2012)
Undergraduate Research Opportunities Program Grant (2012)
14th Annual Undergraduate Research Symposium invited speaker (2012)
Undergraduate Research Opportunities Program Grant (2011)
Dean’s List (2010-2012)
Sigma Alpha Lambda Leadership Induction (2009)
Community Service Award (2008)
National Honor Society (2005-2008)

Social Organizations
Psi Chi (2012-Current)
Society for Neuroscience (2010-Current)
American Association for the Advancement of Science (2010-Current)
Sigma Alpha Lambda (2009-Current)
Pre-Medical Society (2008-2012)
Boston University Red Cross (2008-2012)
Ambassador to the Residence Hall Association (2008-2010)

Conferences
Society for Neuroscience Conference (2011)
National Association for Gifted Children Conference (2006)

Study Abroad in South Africa (2006):
Tshwane (Pretoria) Metropolitan HIV/AIDS Conference
Visited 10 South African Schools
Nazareth House AIDS Hospice and Orphanage