

Digital twins for trans people in healthcare: queer, phenomenological and bioethical considerations

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ABSTRACT

Healthcare is one of the domains in which artificial intelligence (AI) is already having a major impact. Of interest is the idea of the digital twin (DT), an AI-powered technology that generates a real-time representation of the patient's body, offering the possibility of more personalised care. Our main thesis in this paper is that the DT does not merely represent the patient's body but produces a specific body. We argue, from a philosophical perspective and an ethical-phenomenological approach, that the virtual body created by the DT has a major impact on one's self-understanding, having consequences for gender expression and identification, and for health. This has deep implications for people who do not conform to gender normativity, for example, trans individuals. We advocate that, with thoughtful development, DT technology can and should be empowering, contributing to better addressing the diversity of bodies and facilitating trans people's experience in healthcare contexts.

INTRODUCTION

Technologies have a significant impact on how we understand ourselves and how we interact with and relate to the world around us. The most important technological innovation of our present day is artificial intelligence (AI), and healthcare is one of the domains where a major impact is already happening and also expected in the near future. Of particular interest is the idea of the digital twin (DT), an AI-powered technology that generates a real-time representation of the patient's body¹ with the objective, among others, of offering diagnosis and prognosis, testing different treatment options and predicting future health-related events,¹ giving patients the possibility of more personalised healthcare. While DT in healthcare could also refer to a virtual, real-time representation of the whole hospital infrastructure, personnel and services, for management purposes,² we focus here on the DT as a representation of the human body.³ DT technology is predicted to be one of the most significant future technologies in medicine, and although a complete DT of a whole person has yet to be developed, significant advances have been accomplished, for example, in the successful development of a DT of the human heart.⁴

As the name already suggests, DT is closely linked to questions of identity, providing an accurate representation of the patient. While broader ethical considerations regarding the use of DT in healthcare contexts have already been explored in research,^{1,5,6} the sensitive and complex issue of gender identity and the question of appropriate representation that aligns with the self-image of an individual have not yet been addressed.

In this article, we explore the connection between DT and identity, with a particular focus on the gender identity of trans persons. Specifically, we examine how the DT intersects with the gender identity of trans individuals and ask: how should DT be developed in healthcare to assist and include trans people? We identify ethical challenges and opportunities presented by DT technology for trans individuals in healthcare.

We do so to promote a more inclusive development and implementation of DTs in healthcare, aiming for a more inclusive and just healthcare system that strives for health for all. Thus, we consider the ethical analysis of DTs and focus on the marginalised group of trans persons to be crucial. For this purpose, we build on existing medical literature on DTs and adopt phenomenological approaches, as phenomenology captures the human–technology relationships essential for healthcare and identity. We also incorporate bioethical and queer perspectives to provide practical guidance. Gender is socially constructed, hence we need an approach that is sensitive to what identity is and how it is shaped by technology and society. An approach that looks beyond the biological and focuses on construction, power and knowledge production is required.

We argue, from a philosophical perspective and choosing an ethical-phenomenological approach, that the virtual body created by the DT has a major impact on one's own self-understanding, which has consequences for gender expression and health. Regarding the latter, a better understanding of oneself contributes to the individual's autonomy and participation, which facilitates communication in the medical encounter with healthcare professionals (HCPs) and fosters shared decision-making about future treatment paths.⁷ From our perspective, the DT demonstrates very well how, through technologies, an individual's body is not merely replicated and represented but produced from data. As has already been shown in other areas of technology research,⁸ data play a pivotal role in creating a version of the body that is shaped by technological processes and algorithms, rather than being a straightforward copy of the physical body. Our main thesis in this paper is that the DT does

¹While acknowledging the interconnectedness of the body and its psychology, we narrow our research to digital twins of the human body, leaving aside other attempts to develop digital counterparts of the human psyche, usually called 'digital doppelgängers' or 'psychological duplicates'.



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not merely provide a representation of the person's body but produces a specific body image and, therefore, is closely intertwined with questions of (gender) identity. This has deep implications for people who do not conform to gender normativity, for example, trans persons. In this case, the DT could become particularly virulent, as identity here is either in transition or does not conform to the cisgenderist binary matrixⁱⁱ, adding to current struggles related to healthcare access and treatment.^{9 10}

Our use of the term 'trans' is intended to be inclusive of the different gender (minoritarian) identities, following Feinberg's¹¹ view of trans as a plurality. Trans individuals

have multiple ways that they choose to socially transition their gender identity and/or expression that includes changing their name, pronoun(s), and/or undergoing medical transition interventions that include surgery (gender-affirming surgery) and/or cross-sex hormones. Other individuals may decide to have a gender identity or expression outside of the conventional gender binary (male vs female) and are considered gender non-binary people.¹²ⁱⁱⁱ

The main purpose of this paper is to examine the potential benefits, risks and challenges associated with the implementation and use of DTs for trans people in healthcare. By drawing attention to these issues, we do not stop at mere criticism. Instead, we advocate that with thoughtful development, DT technology can also be empowering, making a contribution to better address the diversity of bodies and facilitating trans people's experience in healthcare contexts.

To do this, in section DT technology in healthcare, we introduce DT technology in healthcare and review the current state of research on DT. In section Our approach, we examine how the identity and body of trans individuals are influenced by DT technology. We reflect on the conception of identity and the relationship between the body and technology. In section Conception of identity: reproducing a fluid body, we briefly offer our approach on gender identity and the use of DTs. We investigate in section Ethical implications of DT for trans persons in healthcare, what these insights mean for the development and use of DT for trans persons in healthcare, and we also develop some guiding questions for future research.

DT TECHNOLOGY IN HEALTHCARE

The DT is

a set of virtual representations that enables describing the fundamental characteristics of a physical entity using different levels of abstraction. A DT is a precise and up-to-date virtual manifestation that continuously aggregates data coming from the physical counterpart, thus serving as a central knowledge base for both real-time analysis and forecasting.¹³

The DT is a system of three elements: physical object, virtual representation and data connections between them.¹⁴ The latter

ⁱⁱWe understand 'matrix' as the cultural, social and political environment in which gender norms develop, reinforcing a rigid binary understanding of gender (male/female) while privileging cisgender identities (those whose gender identity aligns with their sex assigned at birth).

ⁱⁱⁱAlthough it might not seem completely clear in the quote, this use of 'trans' as an umbrella term includes gender non-binary people. We have chosen this broad definition to remain inclusive (taking the lived experiences of trans persons seriously) and to avoid creating too many overly specific differentiation categories (and definitions). This approach allows our concept to retain a degree of interpretative flexibility, which can be valuable for broader applicability and a more nuanced understanding when required.

is provided by different technologies, such as (wearable) sensors and AI algorithms, that guarantee a reliable representation of the patient.

In the context of patients in healthcare, the term DT refers to a real-time simulation of the patient's body with the objective, among others, of offering diagnosis and prognosis, testing different treatment options, and predicting future health-related events.^{1 15 16} The appearance of certain medical conditions could be anticipated based on the DT's prediction, preventing their further development or, alternatively, giving HCPs the possibility to test the effects of different available medicines on the DT and identify which one will have the best effect based on the patient's physiological characteristics. DTs are currently being discussed in medical research for biomarker and drug discovery, modelling organs and medical devices, surgical planning, clinical trials, personalised medicine, well-being and mental health.^{3 17}

In the technology discourse, there is repeatedly a plea for human-centred technology. But what does that mean when there is not just one type of human, but a multiplicity of humans and bodies? DTs in medicine will enable personalised treatment and improved diagnosis; thereby, they will provide more accurate medical assistance through the virtual representations of a person.² Thus, it seems promising to bring us closer to the instantiation of P4 medicine (predictive, personalised, preventive and participatory), which offers great opportunities for medicine and healthcare, emerging from the real-time health monitoring technologies implemented⁷: medical services and research can be tailored to the specific needs and biomedical characteristics of the patient.⁵ Although the configuration of DTs for healthcare will have as the main objective the monitoring of health and assessment of treatment options for patients, which initially might seem gender-neutral, it would benefit from the involvement of trans individuals and communities in the design process.¹⁸ [iv]

It is worth noting, as already stated at the beginning of the introduction, that a complete DT of the whole body of a person has yet to be developed. However, far from being an obstacle to reflecting on the impact of this future technology on our bodies and health, now is the perfect time to carefully consider the (bio) ethical implications that it will have on patients.

OUR APPROACH

Despite years of work in queer studies^{19–21} and valuable contributions that emphasise the importance of considering and including transgender persons in healthcare^{9 22–24} reflections, considerations from trans individuals remain far from being fully integrated into healthcare and medical ethics. When they do indeed occur, a considerable part of trans healthcare focuses on transitioning bodies or difficulties in access to services,²⁵ which effectively erases the importance of other aspects of trans healthcare.¹⁰ Following Talbert's¹² systemic literature review on trans-healthcare-related issues, no studies have addressed preventive screening, and only a few focused on primary or preventative care. It is with this preoccupation in mind that the DT needs to be thought of as a means to close the health disparities gap for trans people; for an adequate implementation and use could solve, or at least mitigate, such imbalances. The DT should be developed as a technology that facilitates inclusion into the medical realm of different body ontologies, promoting trans-inclusive

^{iv}Although beyond the scope of this paper, it is important to acknowledge that further queer-inclusive approaches for the development of (healthcare) technology are currently being pursued.

healthcare.²⁶ Moreover, as we know particularly from the field of medicine, technologies rely on a wealth of data that often only reflects male, cis-gender individuals. Thus, medicine contributes to creating a very specific image of humans. With the reflection, examination and assessment of the DT through a queer/trans lens, we also intend to inform those involved in the development and use of DT in healthcare about the importance of addressing the needs of trans persons, by raising awareness of the different realities outside a gender binary frame.

The remainder of this paper will attempt to address the following question: what could/should be done differently to account for the needs of queer people in healthcare so they can be cared for better? How should DT be developed in healthcare practice to assist trans people and be inclusive?

For that purpose, we are taking the next steps:

1. We reflect on the conception of identity, on the relationship between body and technology: how are the identity and body of trans individuals influenced by DT?
2. What does this mean for the development and use of DT for trans persons? We identify 6 areas of ethical relevance.
3. We offer a set of guiding questions for research, development and use of DT for trans persons.

CONCEPTION OF IDENTITY: REPRODUCING A FLUID BODY

To understand the ethical implications of DT technology for trans individuals, we must first examine the relationship between (gender) identity, body and technology. For this purpose, we draw on insights from gender theory and phenomenological-ethical approaches in philosophical anthropology and philosophy of technology.

Lupton²⁷ shows that the ‘DT’ metaphor already strongly suggests a link between this technology and a person’s identity. However, she criticises this metaphor for being misleading in terms of ‘exactitude, inclusiveness and a close human-like relational connection’ that it implies. She makes a crucial point relevant to our discussion: that the term ‘DT’ does not fulfil what it promises—to be a DT of a human being and to precisely represent that person’s identity.

Human identity cannot be understood as a static attribute acquired on reaching adulthood; rather, it is constantly evolving throughout life; it is fluid and dynamic.²⁸ This fluid understanding of identity is not contradictory to assigning certain stability and specificity to it, which is needed at least in the way that we talk about it and (politically) recognise it.^v Moreover, identity is never solely derived from the individual but is always developed in interdependence with relationships, society, politics, technology and the environment. Gender identity is similarly socially constructed and culturally shaped, for ‘what we are able to imagine about what our bodies are or may become (...) is structured by the history of how bodies have been socially understood, by what bodies have been’.²⁹ This does not mean that the materiality of the body is inexistent, nor that gender cannot be reworked, reimagined and embodied.

A general challenge for DTs, therefore, is how they can represent the fluid and dynamic identity of individuals without confining them to a static cis-heteronormative image. While DTs are dynamic, real-time representations of specific biometric

information of the human body, human identity goes beyond that, hence the difficult task they face. Additionally, even a snapshot of an identity cannot be fully articulated or captured in an essentialist manner, because it is always a complex web of social relationships, experiences and body.

Contrary to what could initially be thought, the DT is not an avatar in the traditional sense, for the DT cannot be altered and personalised based on the patient’s preferences.⁶ Still, it is created as a live representation of the current state of their body. However, as is the case with other technological artefacts, DTs will have a significant impact on how we understand and relate to ourselves and our bodies. Similarly, it will play a key role in shaping our self-image, for it is intertwined with our self-conception and identity. For example, we could imagine a case of a DT whose body shape reflects the individual’s, and how that could influence their self-perception in scenarios where the patient suffers from an eating disorder. We can argue here that DTs will have a strong impact on identity, even if they are only used by individuals and exclusively within healthcare. Research suggests that DTs could eventually connect with self-tracking devices and similar technologies, becoming part of everyday tech.^{3 17} It could be objected that DTs would have to become a regular healthcare practice to have a significant influence on identity issues. In such a case, the impact on identities would be even more significant, though we do not aim to speculate on these technological possibilities. However, even if they do not become everyday technologies, DTs will cause identity issues because individual identity is shaped regardless of how many are affected. This is particularly evident with trans persons, where identity is still profoundly meaningful within this context.⁵

In philosophy, there is a long-standing tradition of thought suggesting that (medical) technologies, even those solely for analysis and visualisation, mediate or even change our bodies and/or how we understand and relate to them. Ihde argues that imaging technologies do not merely represent the physical world out there but, to the extent that they create a digital version of it, they are producing such a world.⁸ This postphenomenological approach by Ihde was further developed through the mediation theory by Verbeek.³⁰ Verbeek³⁰ argues that technologies mediate our relation to the world: they ‘shape human experiences and practices’ and ‘help define what it means to be human.’ Medical technologies are, therefore, never merely representations of our bodies, but shape the knowledge we have about it and inform the ‘moral actions and decisions’ we make based on the technology.³⁰ For the DT, this means that the technology will code-terminate how we understand ourselves and how we act.

To the extent that the DT can be understood as a medical imaging technology that accurately depicts the patient’s physiological characteristics, it can thus be said that it is not merely a representation of the individual body, but the production of a virtual body. Our body image is configured differently from the corporeal body, which allows the subject to engage with their corporeality in a back-and-forth process of (re)creation.³¹ This is especially true in the individual case, where our experiences of objectified health, for example, blood test results, are reintroduced in our embodied existence and they become part of the body we live through.³²

Some relational approaches, such as New Materialism (eg, Donna Haraway, Karen Barad), go further and view technologies not simply as mediators but in their constitutive role. Haraway and Barad argue that technologies co-constitute what humans and bodies are. In their view, bodies are not pre-existing entities to be discovered by the natural sciences; rather, they are made

^vWe would like to thank an anonymous reviewer for making us aware of this problematic aspect.

and produced.^{33 34} Technologies, (natural) sciences, culture, society, commercial strategies, capitalism, along with metaphors (such as those of machines and computers) and narratives, together produce the body and define what a body is.³⁵ This means that DT technology will not merely depict or represent a body but will rather co-produce the body itself. If the body is not merely reflected in the DT, but mediated or co-produced by it, special consideration is required for bodies that do not conform to the norm because this technological mediation and co-production shapes identity.

The same holds for the perennial constitution/creation of the trans body:

To affirm a materiality—or to be less abstract, to insist on the livability of one's own embodiment, particularly when that embodiment is culturally abject or socially despised—is to undertake a constant and always incomplete labor to reconfigure more than just the materiality of our own bodies. It is to strive to create and transform the lived meanings of those materialities.²⁹

Rather than concentrating on the constricting and determining character given by the materiality of the body, the trans person holds their body on the threshold of possibilities of what cannot be anticipated, open to different paths to constitute the body's reality.²⁹ It is here where the DT could be of assistance, in the (re)configuration of the transitioning body, aiding the trans person to navigate different alternatives and meanings of the body being transformed for their narratives and identities. How technologies are received once their implementation and use are widespread on a societal level cannot be anticipated. Similarly, we cannot underestimate the material, social, cultural and personal complexities that play a role in how technology is employed,³⁶ neither can we ascertain their mediating character in the subject's experience of their world. However, we can bear in mind the mediating function of the DT as a technological artefact, acknowledging its potentiality to help trans people constitute their bodies.

It has become apparent how influential DT technology can be for the identity and bodies of trans persons. Now, the question arises: what ethical aspects must we particularly consider in the development and use of DTs for trans individuals in healthcare?

ETHICAL IMPLICATIONS OF DT FOR TRANS PERSONS IN HEALTHCARE

Challenges and opportunities

For the trans individual, the question arises as to how their changing gender identity can be represented in the DT in a way that facilitates and positively contributes to a better understanding and perception of their self and also allows for an adequate healthcare service. Instead of a determined conception of gender/sex as fixed, or given, from the moment a person is born. Overall³⁷ offers an approach to trans identity as an ongoing life project. There is an emphasis on personal choice and decisions; our identity is thus, at least to some extent, an act of creation. There is no need to postulate an underlying metaphysical 'true' being that is revealed/attained through transitioning. The DT can be of help in this creation process.

We have identified six ethically sensitive areas crucial for trans persons in the context of the development and use of DT technology (see table 1 for guiding questions regarding these ethical issues). We focus here solely on the concerns of trans persons in healthcare, given the current injustices experienced by trans individuals in these settings and do not provide an overview of

the ethics of DT technology in general. We derive these ethical areas from the preceding description of DT technologies, their specific characteristics (sect. 2), and our gender-fluid approach (sect. 4). This includes both descriptive and normative arguments, drawing on ethical areas already identified by other queer research on different medical technologies.^{23 38}

Data

Like most digital technologies, the DT indispensably relies on data to offer accurate simulations of the body and provide correct diagnosis and prognosis. We already know from medical technologies that they primarily rely on data which often only reflects male, cis-gender individuals, and that female and queer persons are not represented in these data: '(...) the entrenched cis- and heterosexism of our healthcare system and the society in which it operates is repellent and hazardous to trans patients'.³⁹ This means that technologies also reproduce a very specific image of the human being/body, namely the male, cisgender body. Perez⁴⁰ influentially outlined this 'gender data gap' and highlighted its life-threatening consequences. For example, the symptoms of a heart attack vary significantly between men and women, leading to heart attacks often going unrecognised in women. Moreover, when symptoms that occur in trans individuals are not recognised because the data are based only on the male, cis-gender body, it can result in trans individuals not receiving the healthcare needed or life-threatening emergencies not being recognised. Here is where the DT could be of great aid for trans individuals, for the focus would be on the personalisation of medical treatment and diagnosis based on the person and not on population-level data gathered. For example, in cases of hormone replacement therapy (HRT), healthcare practitioners would have access to the process specificities for that concrete trans individual, facilitating a medically adequate and safe transitioning. It allows for a personalised monitoring of the patient's endocrinological status together with more detailed knowledge about the best drug to be prescribed for each individual based on their physiology.⁶

Another important issue that is often overlooked is the data collection methods. Data are not neutral, cannot fully represent identity and inherently incorporate gender-discriminatory structures. Data collection methods already shape the data that being collected. Adequate data collection methods for trans persons involve the creation of non-binary data and allowing more space in studies to incorporate the personal experiences of transgender individuals, instead of merely relying on short, prefabricated surveys. There are already promising approaches inspired by a rhizome to decentralise data ('RhizomeDB'), including a '(Bring Your Own Algorithm) approach',⁴¹ and attempts to queer data, such as 'the queering of collection methods'.^{vi42}

A final key aspect is that data security must be guaranteed for trans persons. Medical data are highly sensitive, and trans individuals are particularly vulnerable to discrimination and persecution by society and politics.

Function, application and access

Applications and functions of DT can be developed to support trans individuals in their identity construction and transition processes. Potential applications could include HRT, as mentioned in the above section, facilitation of surgery procedures,

^{vi}Thanks to Ben Hawken for discussions on Queer Data.

and generally an improvement of the medical encounter. Moreover, together with telemedicine,⁹ the DT could compensate for the lack of physical examination, for it provides HCPs with a live version of the patient and their clinical status. Thus, it could prevent, even during in-person consultations, unnecessary examination of sexual organs, that trans patients commonly find intrusive. Such applications offer valuable support in identity and transition processes. They allow trans persons to construct, together with HCPs, a safe space where their health needs are met without further questioning of their gender and their sexual characteristics. In this way, access to healthcare for trans persons can even be facilitated. Similarly, the DT could be understood and deployed as a technology that facilitates inclusion into the medical realm of different body ontologies, promoting trans-inclusive healthcare and contributing to the education of HCPs by making them aware of the different realities outside the gender binary frame.

However, a concern is that these applications and functions may not be implemented because the DTs will be shaped by heteronormative expectations. It can already be seen in the case of self-tracking technologies in healthcare³⁸ that these technologies have not been designed for trans persons. Due to the discrimination of trans persons in society, politics and even in the healthcare system,¹² it is possible that even if such applications and functions specifically for trans persons exist, access to them may be hindered or made impossible. Access can also be obstructed by higher costs or legal barriers.

Generally, DTs must be designed to be dynamic and open to change. Since (gender) identity is open, dynamic and constantly evolving, the DT should not fixate on an individual's identity but rather must enable individuals, especially transgender persons, to change and self-develop. This approach ensures that the technology adapts to the user's evolving identity and needs, rather than constraining them to a static model. The technology must support the fluid identity and provide tools that help users explore and affirm their evolving selves. In general, DT technology should therefore offer a dynamic DT for identity processes:

... 'trans as movement'¹⁰ can be used to create space for more expansive ontologies of gender that confront the harms and restrictions imposed by the gender binary, and offer alternative ways of (re)imagining multiplicity in trans(ition) trajectories and futures for both those in healthcare delivery, and for trans patients.²⁶

Experiences and values of trans persons

Since identity is closely tied to personal experiences and values, it is crucial to incorporate the experiences of trans individuals in the development and use of DT technology. These experiences must be considered from the very beginning of the technology development process. To facilitate this, more empirical studies are needed to understand how trans individuals experience DT and to identify the challenges and opportunities it presents for trans individuals. To take an example from a different field, disability studies, it has been observed that when disabled persons are asked about their experiences with a technology that is supposedly designed to assist with their disability, they often report that they do not want the technology and find it burdensome.⁴³

Beyond merely considering the needs of trans individuals in technology development, another important aspect is involving trans persons directly in the development process. This participation fosters the creation of the technology by trans persons

themselves, ensuring that their specific needs and perspectives are effectively integrated and addressed:

It matters that trans people are involved in trans technology design processes because trans people need technological solutions to address some of the challenges they face in the world, and these solutions must actually account for and design for users' needs.¹⁸

Embedding identity: context, body, relationships

In the use of visualisation technology in medicine or medical technologies in general, we tend to reduce disease and health, identity and body identity to the biological body, forgetting that these are always closely linked with contexts, from the relationships one has to lifestyle, and much more. A (body) identity represented in a DT is therefore never complete. In the context of DTs, first, the perspective should be broadened to recognise that not everything is captured in them, and a reductionist medicobiometrical understanding of identity should be avoided. Second, options should be explored for how these many other dimensions of identity can be represented in the DT. While we acknowledge that identity and health are not only about the body, the DT can positively contribute to the mental health of the individual by recognising and showing the particularities of the trans body and identity. It might be here, to the extent that it will be technologically feasible, that some personal traits of psychosocial character could be included as extra support to strengthen the particular DT of the individual, facilitating a tailored delivery of healthcare services. Finally, it is important to note that an exclusive focus of the DT as an assisting tool on the transition surgery could contribute to a partial understanding of trans realities, reaffirming sexual and gender binaries within already heteronormative societies 'a postoperative aspiration of living according to the heteronormative order'.⁴⁴

Discrimination, stereotypes and power dynamics

Barad's³⁴ and Haraway's^{33 35} approach, which posits that the body is not simply given but is produced through many actors, also allows for the uncovering of power relations hidden within body images and technologies. In DTs, certain logic, structures, stereotypes and discriminations that are prevalent in society (and among technology companies and developers) are reproduced. Therefore, DT technology requires a discrimination-sensitive perspective. Which structures, logic, stereotypes and discriminations are reproduced in digital twins?

Additionally, the question arises as to who has the power to co-shape the user's body in DT technology. The design of the technology and functions, such as live representation and monitoring of vital functions, always shape the body as well. Nosthoff and Maschewski⁴⁵ illustrate, using the example of the Apple Watch, how companies like Google and Apple are striving for a 'mapping of human health' through the smartwatch and the extensive health data it gathers, similar to what has already been done with Google Earth or Google Maps. These private companies significantly shape our understanding of health, possessing what Bourdieu calls 'naming power'.⁴⁶ They establish guidelines, define the boundary between health and illness and declare these boundaries universally valid. Lupton argues on similar grounds, stating that the metaphor of the DT in healthcare contributes to an understanding of health that is highly appealing to us given its associated notions of

personalisation and control, and a promise of ‘efficacy and certainty that is hard to resist’.

The development of DTs in healthcare for trans people needs to be mindful of the power dynamics mentioned above to guarantee they have a minimal impact on the individuals using them.

Agency and autonomy

The power to co-shape one’s body and identity with DT technology should reside with the trans individual themselves. DTs should be implemented in healthcare practice to enhance the individual’s autonomy in medical decision-making processes. Therefore, a central question for the development and use of DTs should be: How can the technology promote the autonomy of transgender individuals? Initially, we believe that, to the extent that DTs’ information could be accessed by trans patients, it might be empowering to manage specific treatment options, for example, HRT, by situating the individual in a better epistemic position. For instance, this would mean that rather than issuing clear directives or classifying human phenomena into fixed categories and types, DTs should allow individuals as much room as possible to shape the DT through open formats and to use it autonomously according to their own needs.

Using self-tracking apps as an example, Lupton⁴⁷ shows how technology produces new ‘human–nonhuman agencies’ or ‘assemblages’, in which technology and people act together, and autonomy and agency are not solely the domain of individual humans but always take place within a network of humans and technology. This means that the autonomy of the human individual is transformed with the DT and must be understood within the human–DT assemblage. The decisions made by the trans individual are also influenced by the DT and the relationship the trans individual has with the DT.

Similarly, in cases of medical transitioning, the DT can contribute to shifting away from a disease-based model to one where the focus lies on the trans individual identity, enabling them ‘to have greater agency over their bodies as they engage with the medical system, making previously invisible, non-linear transition paths visible’.²⁶

On the other hand, we need to be aware of, and prevent, a return to medical paternalism in a digitalised version of it.⁴⁸ Currently, HCPs are, with the use of new AI-powered technologies such as the DT, producing knowledge about, and thus having power over, trans people and their realities emerging from these medical processes.¹⁰ Similarly, the DT could unveil the trans reality of a patient who consults their HCPs for another condition and who would not feel comfortable coming out to the HCP. The latter would be a case where the DT becomes a whistleblower of the trans reality that the person does not want to disclose. These are two examples of scenarios where the deployment of DT in healthcare for trans people would potentially hamper their autonomy.

Guiding questions for the development and use of DT for trans persons in healthcare

Based on the six points identified in Section 5.1., we develop the following guiding questions for the use and development of DT for trans persons (see table 1 below). It is crucial that the experiences, feelings, values and needs of trans persons are centrally considered in DT development. For this purpose, it is important to conduct many empirical studies to determine the needs of trans individuals and their relationship with the DT, as well as to integrate trans persons in the cocreation and codevelopment of DT. The following questions can guide the use and development of DT.

Table 1 Guiding questions for the development and use of DT for trans persons in healthcare

Data	<ul style="list-style-type: none"> ▶ Are data from transgender persons appropriately included in the datasets? ▶ Are the data collection methods adequate to represent the bodies and experiences of transgender persons? ▶ Are the data handled responsibly and are the vulnerable data of transgender persons protected? ▶ Could the DT facilitate self-medication if patients have direct access to the data gathered? Or will it become a whistleblower to HCPs of health misconduct?
Function, application and access	<ul style="list-style-type: none"> ▶ For which applications can digital twin (DT) technology be used for transgender persons, and for which applications is it not suitable? ▶ Where do problems arise in the use of DT for transgender persons that are unique to transgender persons and therefore can be easily overlooked? ▶ Is low-threshold access to digital twin applications, from which transgender persons can benefit, made available to them? ▶ Could the DT contribute to the experience of one’s own body as an alienated body?
Experiences and values of trans persons	<ul style="list-style-type: none"> ▶ What experiences do transgender individuals have with DT? How can their experiences, which they gather in other contexts, and their personal values, enter into DT? ▶ Co-creation and co-development: Are transgender individuals involved in the development of the DT technology?
Discrimination, stereotypes, and power dynamics	<ul style="list-style-type: none"> ▶ Which logics, stereotypes, and discriminations are reproduced in the DT? ▶ Could the DT allow HCPs and trans people to focus on the body, without considering gender, and where sexual characteristics are not used within the cisgenderist matrix? ▶ Where are the problematic power structures in the development of DT and its use in healthcare: Who is producing the trans body with the DT? ▶ What intersectionality issues arise?
Embedding identity: context, body, relationships	<ul style="list-style-type: none"> ▶ How can aspects of gender identity that go beyond the biological body, such as lifestyle, relationships, be adequately represented in a DT? Or how can we remain aware of what cannot be captured in a DT? What is lost in the representation of gender identity in a DT? ▶ Could the DT intensify the medicalisation of the queer body? ▶ Could the DT have a (positive) impact on the regulatory criteria determining who’s eligible for transition, which plays a gatekeeping function in healthcare and is faced by plenty of trans people?
Agency and autonomy	<ul style="list-style-type: none"> ▶ How can the DT promote the agency/autonomy of the transgender person? ▶ How do autonomy and agency of the trans person change with the DT? Can the DT positively contribute to an increased sense of agency of trans persons over their bodies?
DT, digital twin.	

CONCLUSIONS

DT is considered an influential and promising technology in healthcare; however, an ethics of DT is still to be developed. At the beginning of DT research, we brought attention to how DT can impact human identity, particularly the gender identity of transgender persons, a group still neglected in healthcare.

For this, we explored the connection between DT and (gender) identity and referred to established ethical theories in phenomenology, queer feminism and bioethics to show that through DT, an individual's body is not merely replicated and represented but produced from data, creating a specific body image. DT cannot be an accurate duplicate of our personal identity, as the name 'DT' misleadingly suggests. This has a significant impact on one's own self-understanding, gender expression and identification. Simultaneously, it also affects health.

Therefore, we asked: how should DT be developed in healthcare to assist and include trans people? We identified six areas of ethical relevance where the implementation and use of DTs both raise challenges and offer opportunities to trans people in healthcare scenarios: (1) data, (2) function, application and access, (3) experiences and values of trans persons, (4) embedding identity: context, body, relationships, (5) discrimination and stereotypes and (6) agency and autonomy. We propose a dynamic DT that is open to constant change and modifications, inclusive of trans persons' experiences, suitable for transitioning bodies, a DT that promotes autonomy. Additionally, we proposed applications in healthcare where DT might support trans persons and identified specific challenges that might arise in the use of DT for trans persons. Based on the six areas, we developed guiding questions for the use and development of DT for trans persons.

Our approach is not without limitations. For example, more empirical studies are needed to explore how trans persons experience and envision DT. Further research should also focus on intersectionality (eg, racism, ableism) and incorporate non-Western perspectives, as many applications cannot be implemented in the same way in non-Western societies that lack the state-funded healthcare systems of wealthier Western societies.

Therefore, we see our approach as a starting point for further research to include trans persons in DT healthcare and to envision futures for a more just and inclusive healthcare system. In this context, we view DT not only as a challenge for trans persons but also seize an opportunity to explore how DT can be empowering for trans individuals.

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