

**Actor-Network Theory Analysis of Personal Protective Equipment in the UK and Its
Relationship to Discrimination Within the National Health Service System
on the Basis of Sex**

STS Research Paper
Presented to the Faculty of the
School of Engineering and Applied Science
University of Virginia

By

Sruthi Gopinathan

April 23rd, 2021

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed: _____ Sruthi Gopinathan _____

Approved: _____ Date _____
Benjamin J. Laugelli, Assistant Professor, Department of Engineering and Society

Introduction

Personal protective equipment (PPE) has been an essential supply for frontline workers during the ongoing COVID-19 pandemic. PPE is a type of tool used by healthcare workers (HCWs) to protect themselves from injury or infection. During the current pandemic, it is one of the primary tools used to mitigate the spread of the SARS-CoV-2 virus (which causes Coronavirus Disease 19 – also known as COVID-19). However, PPE is made to anthropometrically fit men, despite being coined as unisex (Merson, 2020). Given that PPE was not made to fit men and women equally, it contributes to a power dynamic amongst HCWs, where women are disproportionately disadvantaged due to inequity in PPE design. Various news media sources reported on this exact issue within the National Health Service (NHS), the UK’s healthcare system (Merson, 2020; Patterson, 2020; Porterfield, 2020; Topping, 2020). Female¹ NHS HCWs experience greater difficulty using PPE for their work, which limits their role in the workplace and puts them at a higher exposure risk to COVID-19 compared to their male counterparts (Cotrin et al., 2020; Mantelakis et al., 2020; Wielogórska & Ekwobi, 2020).

Although the technological bias designed within PPE is a major factor in the marginalization of female HCWs, this perspective fails to account for the primary actors that allowed for this bias to carry on when recruiting PPE into the network of healthcare products for HCWs in the NHS. It is not one actor, but many actors and their interactions with one another

¹ From the information available on the studies referenced in this paper, it is unclear if the “female” participants referenced in these studies include gender identities outside of cisgender women (i.e. transgender women, transgender men, and gender-fluid or nonbinary individuals whose assigned sex at birth was “female”). However, this paper has been written under the assumption that all participants labeled “female” in these studies include any individual whose assigned sex at birth was “female” because the discriminatory factor in the discussed case study is the anthropometric disadvantage of the discussed technology (PPE for HCWs) towards individuals with anatomically smaller faces and facial features, who statistically tend to be persons whose sex assigned at birth was “female” (Zhuang et al., 2010). For this same reason, any use of the term “female” includes all individuals whose assigned sex at birth was “female”. To prevent misgendering, any individual(s) addressed as “female” and “females” in this paper will be referred to by they/them when using singular pronouns.

that are responsible for this destabilized network. If we continue to think that the technological bias of PPE, or just one other actor, is the only responsible party for the marginalization of female NHS HCWs, we will fail to understand the complexity of the network's flaws and the various actor interactions that led to this discrimination.

Drawing on the framework of actor-network theory (ANT), I argue that Public Health England (PHE), a UK executive agency within the Department of Health and Social Care, failed to account for a key actor — the female body which caused the network of PPE in the NHS to become vulnerable. Resultingly, when the network was mobilized as a result of the COVID-19 pandemic, it was instantly unstable and put the majority of NHS staff — female HCWs — in a disadvantaged position.

Using ANT, I will begin by defining key actors and their respective roles within the network of PPE in the NHS. I will then explain how PHE was identified as the network builder. After this, I will walk through PHE's process of network building — referred to as translation — to identify where during the steps of translation PHE failed and the resulting downstream effects. To support my argument, I will analyze evidence from research articles, news sources, and UK government documents and guidelines which provide information about the various actors of the network of PPE in the NHS and how they relate to one another.

Literature Review

While some scholars have gathered data that highlights the technological flaw of PPE masks in their disproportionate fit failure on female HCWs, these scholars do not address the social factors that have led to this technological failure. Resultingly, these scholars fail to identify the full underlying issue causing this inequity (Hignett et al., 2021). Other scholars have

examined the adequacy of PPE guidelines set forth by PHE for NHS HCWs (Thomas et al., 2020). However, these scholars fail to address how these inadequacies may be marginalizing specific demographics within the NHS, thus failing to recognize the impact of social and political organizations on the perpetual discrimination of individuals on the basis of sex.

A study conducted by Hignett, Welsh, and Banerjee surveyed NHS staff on PPE ergonomics. The authors of this article suggest that there is a limited discussion regarding PPE design despite the numerous UK HCWs who died during the first wave of the COVID-19 pandemic. The results of the survey conducted by the authors demonstrate that wearing PPE caused fit issues for NHS HCWs, with more issues reported by women for all PPE, including facemasks. These reported issues were not only related to fit and protection concerns, but also issues with masks limiting the clinical task abilities of NHS staff (Hignett et al., 2021). This article highlights how PPE technology failed and whom it failed, but not why it failed. Understanding why the “unisex” design of PPE is made to anthropometrically fit men and how design standards failed to accommodate female HCWs, even though 77% of NHS workers are women, can provide a more holistic view of this sociotechnical issue (Hignett et al., 2021; Wielogórska & Ekwobi, 2020).

While some studies surrounding the issue of ill-fitting PPE for women focus on technical actors like PPE, other studies hone in on organizational actors, like PHE. One study discusses the concerns that people in the UK have towards the PHE guidelines that were set forth during the COVID-19 pandemic (before and after revisions to the guideline were made) (Thomas et al., 2020). According to the research done in this study, PHE guidelines seem to fall short in protecting HCWs compared to guidelines placed in other countries. The study demonstrates this

by comparing PPE standards for different healthcare scenarios between PHE guidelines and guidelines from other countries' organizations— such as the US Center for Disease Control and Prevention. For example, in certain patient care situations that other countries deem as requiring N95 or FFP2 — the European equivalent of the N95 —respirator facepieces for HCWs, the PHE guidelines state that only a surgical mask is needed when interacting directly with patients in these care situations (Thomas et al., 2020). Based on this information, as well as the fact that PHE guidelines do not follow the standard recommendations of mask use set by major mask manufacturers like 3M, this article argues that the concerns regarding the adequacy of the guidelines are justified and that the PHE guidelines need revision in order to properly protect NHS HCWs. This article succeeds in demonstrating that PHE guidelines fall short relative to PPE guidelines set in other countries, thereby identifying a key actor responsible for the marginalization of female HCWs. However, it does not look into the specifics of why the technology itself is failing and why it is mainly failing for women. By also focusing on this secondary aspect of the PPE issue in the UK, the authors of the article would be able to recognize that guidelines are failing not just because safety standards are too low, but also because design standards are too low to functionally protect all HCWs, specifically females.

In this paper, I will use the framework of ANT to identify the relationships between the actors mentioned in the aforementioned papers, as well as other actors in the network of PPE in the NHS. I will also explain the actions, or lack thereof, by the primary actor (PHE) in forming this network to provide a more robust picture of how the marginalization of female HCWs in the UK has been perpetuated during the COVID-19 pandemic.

Conceptual Framework

My analysis of the sex discrimination of PPE towards HCWs in the NHS draws on the sociotechnical framework of ANT. This framework allows me to identify the key actors in the network that permitted the creation of PPE with inequitable design and where, in the process of developing that network, the root of this issue lies.

ANT is a method used to organize and analyze complex sociotechnical systems. Actor-networks are systems of interrelated heterogeneous elements — human and non-human actors — that function under a common goal (Callon, 1987). These actor-networks are built by network builders — primary actors responsible for creating and maintaining the network (Callon, 1986). Sometimes, in the process of building and maintaining a network, the network is challenged by a rogue actor which may make the network unstable. I will be using the ANT framework, as developed by Michel Callon, which focuses on the heterogeneous elements that make up a network and how the relationships between these actors in the network are developed through the process of translation.

Translation is the way in which network builders create an actor-network (Callon, 1986). This process is achieved through four stages: *problematization*, *interessement*, *enrolment*, and *mobilization*. During *problematization*, the network builder defines the purpose of the network by identifying a problem or goal as well as the actors needed for that network. Additionally, the network builder determines the obligatory passage point (OPP) that all other actors in this network must go through. Creating the OPP and organizing the actors around it allow the network builder to make themselves essential to the network. *Interessement*, the second stage, is where the network builder actually recruits the other actors to participate in the network they are

building. After this, the network builder designates roles to all other actors in a stage called *enrolment*. In the last stage, *mobilisation*, the network builder secures its role as the spokesperson for other actors in the network and aims to get the actors to begin their roles in the network. If the network builder successfully develops this network through the stages of translation, it has created a stable network, otherwise known as a black-box (Law, 1992).

When the primary actor building a network fails in its process of translation, the resulting built network becomes vulnerable (Law, 1992). A few ways in which vulnerabilities can arise are if the network builder forgets to take into account an actor, if the network builder fails to establish relationships between actors, or if the network builder fails to align other actors' goals with the network's goals. These mistakes can happen in various stages of the process of building a network.

In the analysis that follows, I will begin by identifying the primary actors that built the network of PPE in the UK. After this, I will walk readers through the stages of translation that these primary actors followed and pin point at which stage these actors failed and how they failed in creating a stable network. Finally, I will demonstrate how the failures of the primary actors led to a vulnerable network during the ongoing COVID-19 pandemic.

Analysis

Elements of the Network

To understand the failures and vulnerabilities of the network of PPE in the NHS, it is important to understand the organization of the actors in the network. I have compiled a list of some of the key heterogenous actors in this network and developed an actor-network diagram of

these actors (as seen in Figure 1), based on UK government documents and research articles related to the subject of the failure of PPE in the UK (Hignett et al., 2021; Regulation (EU) 2016/425 of the European Parliament and of the Council of 9 March 2016 on Personal Protective Equipment and Repealing Council Directive 89/686/EEC (Text with EEA Relevance), 2016; Thomas et al., 2020). The identified actors are as follows: (i) NHS, the public healthcare system in the UK; (ii) PHE, an organization that performs COVID-19 response work by providing guidelines and safety information to the NHS; (iii) COVID-19, the actor responsible for PHE building the network; (iv) UK government regulating bodies (GRBs), multiple government agencies responsible for creating and enforcing guidelines related to medical technology; (v) regulatory guidelines, the documents created by UK GRBs that restrict technological design; (vi) PPE the technology taken from the network of construction industry technology to be used by HCWs to protect them from exposure to COVID-19 while they are working; (vii) manufacturing companies, companies like 3M with engineers that design and build PPE; (viii) and the female body, a relevant actor that was not recognized by the network builder of this network. PHE is the communicator between the NHS and all other parties that provide information or supplies to the NHS. Various studies and NHS HCW testimonials have reported complaints regarding issues with ineffective COVID-19 measures put in place by PHE (Patterson, 2020; Porterfield, 2020; Topping, 2020; Trades Union Congress, 2017). PHE operates as the network builder that connects all other actors in this network; it formed the network of PPE in the NHS, by going through the steps of translation.

Network Formation

The first step taken by PHE to build this actor-network of PPE in the NHS is *problematization*. In this stage, PHE overlooks the female body as an actor in the actor-network. This mistake sets in motion a domino effect of growing network instability as the network forms. During *problematization*, PHE determined that NHS staff needed protection from exposure to SARS-Cov-2 during the ongoing COVID-19 pandemic. To create a network that achieves this goal, PHE first identified key actors. PHE identified these actors as follows: the NHS, as an actor needed to provide guidance on safety practices; UK GRBs, as an actor to inform the guidelines that would be enforced onto the NHS; PPE, as a technological actor to physically protect HCWs; and the COVID-19 virus, as an actor to inform other actors how to act in accordance to the ongoing public health crisis.

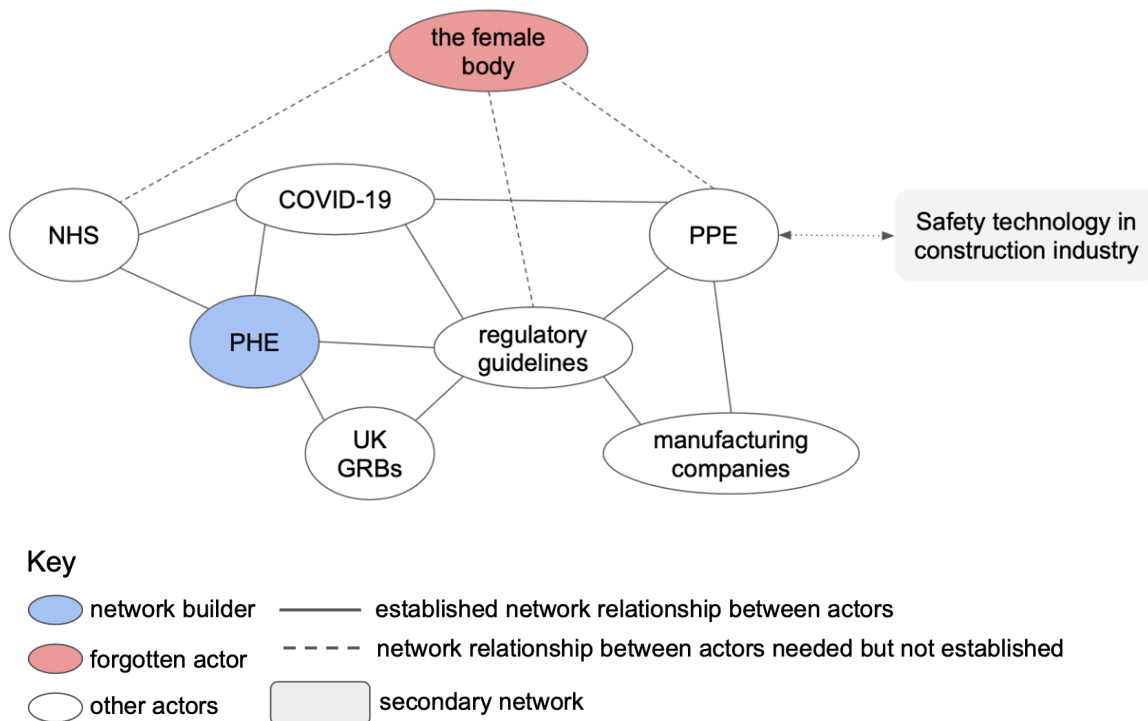


Figure 1 – Actor-network diagram of PPE in the NHS.

In recruiting these actors alongside other important actors for developing this network, PHE failed to identify a key actor: the female body. The female body is an important actor to recognize in this network because women make up 77% of the NHS staff (Wielogórska & Ekwobi, 2020). Due to the lack of gender diversity in engineering across industries, technologies are often manufactured with a technological bias (Weber, R.N., 2009). Oftentimes, technologies that are designed as “unisex” are based on male anthropometrics and thus fail to fit the female body (Weber, R.N., 2009). This issue arises in this specific case because PPE, the technological actor identified to protect HCWs, originally existed in a separate network that had a different gender demographic than the healthcare system in the UK. This other network was designed with the goal of protecting construction workers, and 89% of the construction workforce is male (Ghani, R., 2017). Thus, when engineers design PPE — like facemasks — to protect construction workers they are designed with the technological bias of being made to fit men. A summary from a study done on PPE fit for female construction workers identified, through focus groups, that the majority of participants reported fit issues with various types of PPE they were required to use for their jobs (Ghani, R., 2017). One common issue reported in the study was that the PPE was too large. Resultingly, female construction workers were exposed to safety hazards as a result of the poor fit and felt as though their safety was not valued or prioritized (Ghani, R., 2017). The study provided clear evidence that the improper fitting of PPE impacted safety, productivity, and employer-employee relationships for female construction workers. This technological design bias can be contributed to the lack of representation of females in the construction industry but also the engineering industry, which designs this technology.

According to the Engineering UK 2018 report by the Women’s Engineering Society, 12.37% of all engineers in the UK are women (Women’s Engineering Society, n.d.). This lack of

sex representation in the engineering industry directly contributes to technological bias outcomes as seen in the construction industry. Engineers often design with a specific set of users in mind, and those users are often assumed to be similar to themselves (Weber, R.N., 2009). Thus, we see the issue of men designing technology, like PPE, for men.

Consequently, during *interressement* (the second stage of translation), when PHE recruited PPE as an actor from the network of construction safety tools into a network for protecting UK HCWs during the COVID-19 pandemic, PPE as an actor did not have the right goals for the majority demographic of NHS HCWs — women. Moreover, since PHE had failed to identify the female body as a key actor in the actor-network it was building, it would fail to assign roles to actors in the network such that a relationship was established between PPE and the female body.

As previously mentioned, PPE came into the network with goals that did not align with the female body. This missing alliance between the two actors was the driving factor in the failure of this network. However, some individuals argue that it is the technological bias of PPE that is mainly to blame for the gender discrimination faced by female NHS HCWs (Turner & Marshall, 2020). Although technological bias is a key issue relevant to the overall structural deficiency of the UK's PPE network, the failure to establish a relationship between PPE and the female body is the main reason for the network's vulnerability because it reinforced the technological bias of PPE throughout the network. More specifically, the missing relationship also affected the relationships of both PPE and the female body with other actors in the network, such that it further bolstered the male-biased PPE design. ANT helps demonstrate that power — and fault — do not reside with any one actor, rather it is the interconnection between many actors that establishes and maintains power dynamics (Latour, 1986). One key actor that demonstrates this is the regulatory guideline on PPE manufacturing created by UK GRBs

(Regulation (EU) 2016/425 of the European Parliament and of the Council of 9 March 2016 on Personal Protective Equipment and Repealing Council Directive 89/686/EEC (Text with EEA Relevance), 2016). This guideline explicitly states that all PPE users should be protected. However, since no relationship will be established between PPE and the female body in the network, it will also not be established between the female body and the guidelines, resulting in a misaligned relationship between PPE and the guideline. This failure of relationship, which can be seen in the final two stages of translation, will strengthen the technological bias of PPE.

In the third stage of translation — *enrolment* — where the network builder designates roles to actors, we see this issue of misaligned relationships. The role assigned to the UK GRBs would be to create guidelines and regulations for safety practices and technology designed for the healthcare settings. If the female body had been recognized as a key actor from the start, this organizational actor would have been given the role of working with the actor of the female body and PPE such that these two actors would work together rather than against each other. As we will see in the next — and final — stage of translation, this never occurred.

Mobilisation, the final stage of building a network, was the period in which PHE mobilized the actors it had recruited into its network. As the actors in the network began to perform their roles, UK GRBs started creating guidelines for PHE on how PPE should be manufactured to ensure the protection of HCWs. As seen in Section 1.1.1 (General Requirements Applicable to all PPE – Ergonomics) of Annex II of Regulation (EU) 2016/429 of 9 March 2016 on personal protective equipment, it is stated that face masks (PPE) intended to protect the wearer (HCWS) “must be designed and manufactured so that, in the foreseeable conditions of use for which it is intended, the user can perform the risk-related activity normally whilst enjoying appropriate protection of the highest level possible” (Regulation (EU) 2016/425 of the

European Parliament and of the Council of 9 March 2016 on Personal Protective Equipment and Repealing Council Directive 89/686/EEC (Text with EEA Relevance), 2016). This guideline was presented by PHE to manufacturing companies, like 3M, that were creating facemasks that would be given to NHS HCWs. Although the regulatory document states that PPE should ergonomically protect users (which technically includes female HCWs), since the female body was not accounted for as an actor by PHE, PPE was never re-designed for *all* human bodies within the healthcare industry. Resultingly, the network was set to fail female HCWs, and thus a majority of the UK's NHS. The vulnerability of this network quickly came to light as PPE was urgently needed for NHS staff. News media coverage and research studies began to report female HCWs being disproportionately exposed in healthcare settings (Patterson, 2020). This information was shown through relative mask fit test failures; these failures were significantly more common for female HCWs than their male counterparts (Patterson, 2020). It was also displayed through various testimonials from female NHS staff explaining how masks are “restrictive” and “designed for a 6 foot 3 inch bloke built like a rugby player” (Porterfield, 2020).

Conclusion

The COVID-19 pandemic led to PHE establishing an actor-network to protect HCWs as they do their jobs during this more chaotic time. Although well-intentioned, the PHE's failure to create a stable network, as a result of not recognizing the female body as a key actor, led to serious detrimental effects in the NHS. Resultingly, PPE — like many technologies — although claimed to be “unisex” has been designed for the male body (Merson, 2020). The failure of this network has allowed the technology of PPE to shape power relations between men and women in the UK's healthcare system. The inequity of this vital equipment between men and women in NHS healthcare professions coupled with the pre-existing structural issue of gender bias

globally, perpetuates an environment of gender discrimination in regards to social factors in the workplace as well as health risk factors of employees (Mantelakis et al., 2020). This gender bias that exists within PPE has led to the continued marginalization, endangerment, and disempowerment of female HCWs.

Using the ANT framework helps understand the complexity of many sociotechnical systems like this one. With the information gathered through the lens of ANT, key points of vulnerability and causes of vulnerability in networks can be identified, but not just to put all the blame on one actor. This paper analyzes how the PHE failed, but it is also important to look into why the PHE failed. Because the how shows us what to focus on and the why shows us what to do about it. As of August of 2020, the UK government has decided to completely scrap the PHE ("Public Health England," 2020). Public Health England will be replaced by the new National Institute for Health Protection, which will combine the PHE with NHS Test and Trace and the Joint Biosecurity Centre, in the spring of 2021 ("Public Health England," 2020). This decision by the UK government to nix the organization is coming under scrutiny because it appears to be making the PHE a scape-goat. Although the PHE did fail in creating an effective network to protect *all* HCWs during the COVID-19 pandemic, it is important to understand why it failed to do so. Some PHE officials claim that the organization was limited due to a lack of a proper budget and a lack of investment in public health labs ("Public Health England," 2020). Understanding why the organization failed can help inform appropriate actions to fix the issue of gender discrimination, which may or may not be replacing PHE. The key point is for the decision — whatever it may be — to be robustly informed, which ANT can help do.

It is the responsibility of engineers to use socio-technical frameworks to analyze technologies and the actor-networks they exist in to create a world where technology is designed

for everyone. Universal design must mean *universal* design. And, if one cannot create technologies where “one-size” actually fits all, then one must come up with other solutions to design equitably. In a world where systemic discrimination creates power imbalances that control the lives of many, engineering provides an opportunity to create a more equitable world, where anything is possible for anyone. Engineers have always been able to shape societies, but with the knowledge and awareness of *how* they shape societies, they can build better ones.

Word Count (without footnote): 3693

Word Count (with footnote): 3855

References

- Callon, M. (1986) Some elements of a sociology of translation: The domestication of the scallops and the fishermen of St. Brieuc Bay. In Law, J. (ed.) *Power, Action & Belief: A New Sociology of Knowledge?* London: Routledge & Kegan Paul.
- Callon, M. (1987). Society in the making: The study of technology as a tool for sociological analysis. In Bijker, W., Hughes, T., & Pinch, T. (eds.) *The Social Construction of Technological Systems*. Cambridge: MIT Press.
- Cotrin, P., Moura, W., Gambardela-Tkacz, C. M., Pelloso, F. C., Santos, L. dos, Carvalho, M. D. de B., Pelloso, S. M., & Freitas, K. M. S. (2020). Healthcare workers in Brazil during the COVID-19 pandemic: A cross-sectional online survey. *INQUIRY: The Journal of Health Care Organization, Provision, and Financing*, 57.
<https://doi.org/10.1177/0046958020963711>
- Ghani, R. (2017). Is PPE working for women? *Occupational Health at Work*, 13(6), 32–35.
- Hignett, S., Welsh, R., & Banerjee, J. (2021). Human factors issues of working in personal protective equipment during the COVID-19 pandemic. *Anaesthesia*, 76(1), 134–135.
<https://doi.org/10.1111/anae.15198>
- Mantelakis, A., Spiers, H. V. M., Lee, C. W., Chambers, A., & Joshi, A. (2020). Availability of personal protective equipment in NHS hospitals during COVID-19: A national survey. *Annals of Work Exposures and Health*. <https://doi.org/10.1093/annweh/wxaa087>
- Merson, A. (2020, April 16). Unions say coronavirus crisis has brought “into sharp focus” the problem of women being expected to wear PPE designed for men. *Press and Journal*.
<https://www.pressandjournal.co.uk/fp/news/politics/uk-politics/2142580/unions-say->

coronavirus-crisis-has-brought-into-sharp-focus-the-problem-of-women-being-expected-to-wear-ppe-designed-for-men/

Patterson, C. (2020, May 11). *In harm's way*. The British Medical Association.

<https://www.bma.org.uk/news-and-opinion/in-harm-s-way>

Porterfield, C. (2020, April 29). A lot of PPE doesn't fit women—and in the coronavirus pandemic, it puts them in danger. *Forbes*.

<https://www.forbes.com/sites/carlieporterfield/2020/04/29/a-lot-of-ppe-doesnt-fit-women-and-in-the-coronavirus-pandemic-it-puts-them-in-danger/>

Public Health England to be scrapped over Covid handling. (2020, August 17). *Pharmacy Magazine*. <https://www.pharmacymagazine.co.uk/public-health-england-to-be-scrapped-over-covid-handling>

Regulation (EU) 2016/425 of the European Parliament and of the Council of 9 March 2016 on personal protective equipment and repealing Council Directive 89/686/EEC (Text with EEA relevance), Pub. L. No. 32016R0425, 081 OJ L (2016).

<http://data.europa.eu/eli/reg/2016/425/oj/eng>

Thomas, J. P., Srinivasan, A., Wickramarachchi, C. S., Dhese, P. K., Hung, Y. M., & Kamath, A. V. (2020). Evaluating the national PPE guidance for NHS healthcare workers during the COVID-19 pandemic. *Clinical Medicine*, 20(3), 242–247.

<https://doi.org/10.7861/clinmed.2020-0143>

Topping, A. (2020, April 24). Sexism on the Covid-19 frontline: “PPE is made for a 6ft 3in rugby player.” *The Guardian*. <https://www.theguardian.com/world/2020/apr/24/sexism-on-the-covid-19-frontline-ppe-is-made-for-a-6ft-3in-rugby-player>

Trades Union Congress. (2017). *Personal protective equipment and women* (pp. 1–12). Trades Union Congress.

Turner, M. C., & Marshall, S. D. (2020). Can gendered personal protective equipment design account for high infection rates in female healthcare workers following intubation? *Anaesthesia*. <https://doi.org/10.1111/anae.15206>

Useful Statistics. (n.d.) Women's Engineering Society.
<https://www.wes.org.uk/content/wesstatistics>

Weber, R.N. (2009). Manufacturing gender in commercial and military cockpit design. In D.G. Johnson & J.M. Wetmore (Eds.), *Technology and society: Building our sociotechnical future* (pp. 265 - 275). Massachusetts Institute of Technology.

Wielogórska, N. L., & Ekwobi, C. C. (2020). COVID-19: What are the challenges for NHS surgery? *Current Problems in Surgery*, 57(9), 100856.
<https://doi.org/10.1016/j.cpsurg.2020.100856>

Zhuang, Z., Landsittel, D., Benson, S., Roberge, R., & Shaffer, R. (2010). Facial anthropometric differences among gender, ethnicity, and age groups. *The Annals of Occupational Hygiene*, 54(4), 391–402. <https://doi.org/10.1093/annhyg/meq007>