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SYDE 161
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Situation of Concern Research Document - DIY COVID-19 Facemasks

[1] A. Davies, K.-A. Thompson, K. Giri, G. Kafatos, J. Walker, and A. Bennett, "Testing the Efficacy of Homemade Masks: Would They Protect in an Influenza Pandemic?," *Disaster Medicine and Public Health Preparedness*, vol. 7, no. 4, pp. 413–418, 2013.

Under the supervision of Jimmy Walker, a leader in water microbiology and decontamination at PHE, a team of researchers at Public Health England compared the capacity of various household materials to filter bacterial and viral aerosols. Facemasks that were sewn using a sewing machine were investigated. The materials tested include 100% cotton (specifically 100% cotton materials and products listed as antimicrobial), cotton mix, linen, silk, as well as a vacuum cleaner bag. A surgical mask was used as a control. In particular, the protection capacity of each material was tested by placing cutouts of each type in a humidity-controlled chamber and applying an aerosol to it at a constant speed. In addition, filtration testing was conducted by measuring the difference in concentration of microbial particles between the inner and outer surfaces of each mask, upon two-hour wear by test subjects. The results indicated that the most effective material was the vacuum cleaner bag, followed by two layers of cotton tea towel. A weakness of this study is that the speed at which the aerosol was applied was 3 to 6 times that of regular human breathing, but less than 0.1 times that of a human cough, meaning that the results are not fully representative of human behaviour during the coronavirus pandemic. This source will be useful for the SYDE 161 design project because it provides recommendations for effective material to be used as a face mask based on a peer-reviewed scientific study (two layers of cotton tea towel), as well as providing possible testing methods for effectiveness of filtration, including aerosol chamber testing and microbial concentration testing. These methods could be simplified in order to be carried out using household supplies, using an aerosol such as an air freshener as a replacement for the former method, for example.

[2] W. Hao, A. Parasch, S. Williams, J. Li, H. Ma, J. Burken, and Y. Wang, "Filtration performances of non-medical materials as candidates for manufacturing facemasks and respirators," *International Journal of Hygiene and Environmental Health*, vol. 229, p. 113582, Jul. 2020.

A team of researchers in the Department of Civil, Architectural and Environmental Engineering at Missouri University of Science and Technology as well as the Centre for Atmospheric Particle Studies at Carnegie Mellon University explored the effectiveness of household materials in filtering SARS-CoV-2, with an emphasis on non-fabric materials. The study concluded that the fabric materials tested (e.g. scarves, bandanas) are ineffective in filtering aerosol particles of the virus with sizes ranging from 30-600 nm. However, these materials succeeded in preventing inhalation of droplets, which is another significant mode of spread of SARS-CoV-2. In contrast, filter materials, namely household air and coffee filters, demonstrated a greater capacity to block 0.3 um aerosol particles (the chosen test standard for this study). Specifically, two layers of 1900-MPR air filter demonstrated a filtration efficiency of 99.0%, whereas one layer of coffee filter demonstrated an efficiency of approximately 50%. An important characteristic that differentiates air filters from other household filters (e.g. vacuum bags) is the pressure drop that occurs as air flows through the mask pores. Vacuum bags were shown to induce a high-pressure drop of 1.6 kPa, as compared to that of four layers of air filter (0.6 kPa). Overall, the researchers recommended a 3-layer homemade mask design—a layer of air filter between two fabric layers, which would ensure adequate filtration while preventing inhalation of fibrous particles from the air filter. This could be tested in the 161 Design project. Though the information provided in this article is peer-reviewed and accurate, the selection of materials that were tested was specific to the US market (e.g. Brew Rite coffee filters), so the exact materials that were tested may not be available worldwide, which is a shortcoming of the information provided by this resource.

[3] K.-P. Lee, J. Yip, C.-W. Kan, J.-C. Chiou, and K.-F. Yung, "Reusable Face Masks as Alternative for Disposable Medical Masks: Factors that Affect their Wear-Comfort," *International Journal of Environmental Research and Public Health*, vol. 17, no. 18, p. 6623, Sep. 2020.

A study conducted by researchers at Hong Kong Polytechnic University (specifically the Institute of Textiles and Clothing and the Department of Applied Biology and Chemical Technology) focused on the factors affecting the comfort of various face-mask designs available in industry. The tested factors included water vapour permeability, thermal conductivity, and quality of wear. In general, thin masks made of low-density, non-water resistant, knitted fabric were determined to be more breathable. Furthermore, high thermal conductivity and water permeability were shown to be favourable characteristics of a cloth facemask, preventing dampening and deterioration over time. For prevention of gaps between mask edges and the face, a pleated design was determined to be more effective as compared to a structured, "3D" mask design, since the former type conforms more accurately to varying face shapes. Additionally, pleated masks allow for a space between the mouth and the surface of the mask to be present, which increases airflow and thus increases breathability. The article also emphasized the importance of an adjustable nosepiece in minimizing gaps between the contours of the face and the mask. Although this article is peer-reviewed, some evaluated characteristics are vague and broadly-defined, such as "goodness of fit". Moreover, the masks used for testing seem to have been chosen without a control, since each model differs by more than one design characteristic, such as the type of ear support used and overall mask structure. However, the article provides useful insight into the user experience of wearing a mask, and recommendations including the implementation of an adjustable nosepiece as well as pleated fabric, which are design decisions that could be integrated into the SYDE 161 course project.

Simplified Situation of Concern Chart

	People	Processes	Artifacts	Environments	Resources
Facts	Canadians aged 15-24 are 25% less likely to wear a mask than 65 and older age group [4]	Long-term wear tests are limited to 18/19 year-old first year SYDE students	Fabric materials (e.g. cotton) are less effective filtration barriers than air and coffee filters, but more effective in trapping moisture [2]	Large temperature range in Canada (Record low -62℃ in Yukon to record high 45℃ in Saskatchewan) [5]	Specific filtration capacity of fabric/other materials (e.g. coffee filter) cannot be standardized due to variance in products used (e.g. varying thread counts)
Requirements	Must have an adjustable size to accommodate for different face shapes and sizes, including a nosepiece that can conform to the user's face	Must be washable either by hand or using a washing machine (must withstand water temperatures exceeding 100℃), without ripping	A minimum of 3 layers of material must be used to achieve adequate filtration of microbial particles, including an inner fabric layer to trap moisture [2]	Mask must minimize humidity within inner-mask environment by maximizing space between inner surface of mask and nose/mouth to maximize inner airflow, using a pleated design [3]	The mask design must consist of materials present in 95% or more of Canadian households
Constraints	Aesthetic mask design must be simplistic (i.e. a solid colour) to increase wearing incentive for young individuals	Maximum skill level to fabricate mask must not exceed basic sewing skills (use of a sewing needle and thread)	Mask material must not exhibit a pressure drop that interferes with breathing and communication, or incite ear/skin irritation	Mask must not be so bulky/thick that it does not fit inside an average pant/purse pocket when folded once	The time to fabricate a mask must not exceed 30 minutes for user convenience

References

[1] A. Davies, K.-A. Thompson, K. Giri, G. Kafatos, J. Walker, and A. Bennett, "Testing the Efficacy of Homemade Masks: Would They Protect in an Influenza Pandemic?," *Disaster Medicine and Public Health Preparedness*, vol. 7, no. 4, pp. 413–418, 2013.

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[4] News, "Younger Canadians, men less likely to wear masks, according to Stats Canada," *BC Local News*, 10-Jul-2020. [Online]. Available: https://www.bclocalnews.com/news/younger-canadians-men-less-likely-to-wear-masks-according-to-stats-canada/. [Accessed: 02-Oct-2020].

[5] R. R. Krueger and N. L. Nicholson, "Climate," *Encyclopædia Britannica*, 29-Sep-2020. [Online]. Available: https://www.britannica.com/place/Canada/Climate. [Accessed: 02-Oct-2020].