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Chains of Currency: Manilla Money Bracelets, Early Modern Africa and the Ties That Bind

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ABSTRACT
Manilla money bracelets emerged during the early modern period (ca. fifteenth century AD) as a form of currency between western Europe and West Africa, and continued to circulate until the early twentieth century. While there has been little formal scholarship on manillas, narratives abound: some histories cast the bracelets as the blood money of the transatlantic slave trade; others highlight them as the copper source used to make the Benin Bronzes; and still others uphold the manilla as a symbolically important West African cultural object in and of itself. This study begins with a history of the manilla, from its rapid proliferation to its eventual obsolescence. The term "metastasizing symbol" is proposed to describe objects like the manilla, whose propagation is underwritten by unsustainable systems of cultural difference, and thereby contains within itself the seeds for the object's transition to disuse. The authors also describe a portable X-ray fluorescence (pXRF) analysis of nine manilla bracelets from the Yale University Art Gallery (YUAG). When compared to manilla composition data from previous studies and projected into PCA space, the nine YUAG manillas appear most similar to specimens produced in England during the mid-nineteenth century and traded extensively in British West Africa throughout the colonial period.

KEYWORDS
Manilla Money Bracelets; pXRF; Transatlantic Slave Trade; Europe; West Africa; Early Modern Period; European Imperialism; Provenance

INTRODUCTION

Deep in the bowels of the Yale University Art Gallery's (YUAG's) West Haven storage facilities, tucked amid a Pynchonian warren of windowless hallways which Yale purchased from Bayer Pharmaceuticals in 2007,[1] sit nine metal bracelets, barely big enough to fit around a human arm. The shape of all nine is roughly the same: open at the wrist, flared at the ends, a bit like a very small horseshoe (**Figure 1**). These are "manillas": a vague term, likely arising from the Latin word for hand, possibly by way of the Portuguese.[2] Today, the word "manilla" is used to describe any one of the millions of open-wristed metal bracelets that have been circulating among Central Africa, West Africa and Western Europe since the fifteenth century, when they emerged as a form of currency.[3]

The nine YUAG manillas are currently classified by the museum as "iron jewelry". All nine came to the YUAG as part of a donation in 2010.[4] In scores of museum collections and university archives across Europe and North America, the story is similar: tens, sometimes hundreds of these rusty metal bracelets are sitting on shelves and tucked away in cabinets, most of them deemed too unremarkable for gallery display. Meanwhile, throughout the post-colonial Global South of sub-Saharan Africa, manillas adorn the wrists of village elders, military personnel and religious leaders alike.[5]

How, then, did this happen? How did such an unassuming, apparently superfluous object get stuck so firmly, like a speck of dirt, beneath the fingernails of the modern world? The answer is a story of empire and cultural interchange in the early modern Atlantic; it is a story about chattel slavery, about the making of history, and about what will from this point onward be referred to as "metastasizing symbols" — those images, objects and ideas that flow back and forth between peoples, places and times, undergoing a million little tweaks along the way, until in the end they belong to everyone and no one, everywhere and nowhere, the present and the past, all at once.

What follows, therefore, might be framed as a sort of "object biography",[6] written in two parts. The first part is historical: it uses primary sources and existing literature to describe the evolution of the manilla from an anthropological perspective (i.e. a

perspective driven by an awareness of "culture", in the sense of an emergent property of human groups arising from the interactions of individuals with each other and with their environment).[7]

The second part is chemical and involves a composition analysis (via X-ray fluorescence) of the nine manillas in Yale's collections. The results of this analysis are compared to composition data from 153 other manillas, from previous studies.

Figure 1. Nine manilla bracelets from the collections of the Yale University Art Gallery. For the purposes of this study, the bracelets have been numbered using the last three digits of each specimen's museum accession number, all of which start with "2010.6." (e.g. 2010.6.192 = 192, 2010.6.193 = 193, etc.).

BACKGROUND

While manilla-like bracelets seem to have emerged simultaneously throughout western and Central Africa during the early fifteenth century, the idea of "the manilla" as we know it today — i.e. a mass-produced bracelet currency, historically recognized in large portions of both Africa and Europe — probably first appeared somewhere in western-central Africa during the mid-fifteenth century, most likely as a result of political interaction between the Kingdom of Kongo and the newly arrived Portuguese. One of the earliest appearances of the Portuguese word, *manylha*, for example, is in a letter between the royal courts of Portugal and Kongo, dated to 1514 and mentioning the shipment of 1500 copper manillas northward to Europe, along with 150 slaves.[8] Already the contents of this early inventory — manillas and people — previews the bracelet's many precarious entanglements among the brutal horrors of that region during the early modern period, as well as its importance in the plethora of political chess games played out in resistance to early European imperial strategy.[9]

Interestingly, the only manillas known to have been produced in central Africa (**Figure 2**) — in the modern-day Democratic Republic of Congo, within the borders of the region's erstwhile Kingdom — bear striking resemblance to the earliest mass-produced European examples, which were brought to Africa by the Portuguese in the fifteenth century. While precise dating of the indigenous Congolese manillas in **Figure 2** remains difficult given their muddled museum provenances (documents at the Musée du quai Branly in Paris suggest that one of them may have been made as recently as the early twentieth century), they are nonetheless the most visually similar of any African-made manillas to the earliest European-made ones.

There is of course a fair amount of doubt surrounding the chronology of the manilla's Kongolese origin story. Trading documents assembled by the art historian Eugenia Herbert suggest that Dom Afonso, King of Kongo, was already sending copper manillas to Portugal as early as 1506, in order to cement an alliance between the two states.[10] The first appearance of the word "manilla" in the written record is also difficult to discern: early usage could date as far back as 1455, when the Venetian merchant Luís de Cadamosto appears to use a version of the term. In a post-facto account of his trading voyages in West Africa on behalf of the Portuguese crown, Cadamosto notes that when he reached the mouth of the Senegal River in northern West Africa, two local Wolof men asked him for "two manilhas of tin each" in return for relaying a message to his crew.[11] While the undoubted language barrier between Cadamosto and his interlocutors makes it difficult to evaluate the specifics of the men's request, the fact that Cadamosto uses the word *manille* in the original Italian lends weight to the possibility that the Portuguese had already coined the term *manylha* by this early date, as the travel notes upon which Cadamosto based his memoir were originally

meant to be readable by agents of the Portuguese royal court.[2] Regardless of any chronological discrepancies, however, the fact remains that the manilla as a means of intercontinental exchange seems to have strong roots in the fifteenth century relationship between the Kingdoms of Portugal and Kongo.

Figure 2. Examples of manillas produced in Kongo. Left: object number 71.1951.73.338.1 from the Musée du quai Branly in Paris; right: object number Af1950,16.16 from the British Museum in London. Images courtesy of the Musée du quai Branly and the British Museum.

Thus, while the metaphorical "liminal space" that existed during the early modern period between the politics of Europe and those of western Africa is often forgotten in light of Europe's subsequent colonial domination over the African continent, it was precisely in the context of this liminal space that the term "manilla" first appeared. Far from being a quirk of history, this liminality can instead be read as the beginning of the process (culminating in the eventual rise of the transatlantic slave trade, and the massive loss of life that followed) by which "Europe" and "Africa" went from arbitrary geographic units to culturally meaningful entities. In other words, this was the process by which Portuguese, Spaniards, Frenchmen and Englishmen all came to think of themselves as "European", in the sense of (among other things) "not African". It was also the process by which Edo, Yoruba, Bamum and Kongo people came to think of themselves as "African", in the sense of (again, among other things) "not European". Such processes of definition-by-opposition can be applied at many scales (consider, e.g., the ontologies discussed by the writer Frank B. Wilderson III,[12] or the identity politics discussed by the anthropologist Gregory Bateson),[13] but when considered at a scale like this one, involving entire continents and cultures, the anthropologists David Graeber and David Wengrow have recently proposed the use of the term "schismogenesis", meaning the creation of a cultural identity in opposition to a foreign culture or group.[14] With this vocabulary in mind, the manilla can in turn be read as a sort of "vestigial organ" of schismogenesis: a bivalent Euro-African form, holding the continents together.

To better understand this idea, it is necessary to further examine the history of early manilla production. Following the first shipments of manillas northward from Kongo to Portugal,[8] the Portuguese court quickly realized that their access to the high-quality copper ores of central Europe could be an important piece of leverage in their trade with the sub-Saharan kingdom. From at least the second decade of the sixteenth century, Portugal began commissioning the large-scale production of its own manillas for use on all trading voyages to western Africa,[2] mostly via copper mines and merchant houses in Flanders and Germany.[15] In the three years between 1519 and 1522, the number of Portuguese manillas delivered to the West African trading post of Elmina alone surpassed 150 thousand.[16] By 1531, Portugal was exporting an average of well over 100 thousand manillas per year.[17] Thus, while the manilla was viewed on both continents as a primarily "African" form (often to the point of confusion about the bracelet's origins),[18] it was nonetheless a form produced by Europe, according to European perceptions of African desires. In the context of this profound entanglement, it was not long before a full-fledged institutional framework sprung up around the manilla trade. By the mid-sixteenth century, Portuguese manillas seem to have been assigned fixed values at various ports along the West African coast,[2] where the Portuguese traded them for gold and ivory,[10,19] but also for something much more consequential, from the perspective of the individual and the *longue durée* alike: large numbers of enslaved Africans.[15,20]

By the time European manilla production hit full swing in the early sixteenth century, the storm of transatlantic chattel slavery had long been brewing on the horizon.[21] The conquest of the Canary Islands by Portugal and Spain in 1496 (following decades of hard-fought anti-colonial resistance),[22] combined with the Portuguese colonization of the island of São Tomé in 1486 had given Europe a taste for violent overseas empire, which they promptly began exporting to the Americas on a much larger scale.[23,24] Crucially, it had also given Europe a taste for sugarcane, which quickly proved itself to be an extremely valuable crop on the Canary Islands and São Tomé alike.[22] As the working classes across Europe became increasingly addicted to the high-calorie, easy-to-store nature of processed sugar,[25,26] the burgeoning plantation model for sugar production was likewise exported to the Americas, where the decimation of local indigenous populations at the hands of European pathogens and genocides meant that a large supply of foreign labor was required.[27] Beside the bodily perils of enslavement, the kind of slavery that was needed to power Europe's New World sugar plantations — i.e. intergenerational chattel slavery — also required a particularly severe kind of "social

death", in Orlando Patterson's famous phrase.[28,†] While recent scholarship by historian David Eltis and others suggests that it may have been significantly cheaper for Europe to source slaves from within its own populations,[27] in the context of the schismogenesis that was occurring at that moment between Europe and the rest of the world (and, as discussed above, between Europe and Africa in particular), European empires ultimately turned to sub-Saharan Africa in order to obtain the type of non-human "other" suitable for plantation labor. As New World colonies continued to refine the model for plantation production throughout the seventeenth and eighteenth centuries,[29,30] profits and productivity only increased, and soon all of Europe's empires were engaged in the transatlantic slave trade.

Among other things, this placed a massive stress on Africa's population dynamics. Conservative estimates place the number of people taken from the continent between the fifteenth and nineteenth centuries at around 12 million via the Atlantic ocean,[31] plus several million more via the Indian Ocean and North Africa.[22] This demographic drain is thought to have reduced Africa's population to half of what it would have been by 1850, had the slave trade not occurred.[32]

The effects of such a catastrophe on cultural identities and political structures within western Africa have been well-documented.[32,33,34] The cycles of warfare and unrest driven by the slave trade (for instance in the Kingdom of Kongo)[35] can be thought of as having accelerated schismogenesis between Africa and Europe in a positive feedback loop: as entire African political economies formed and dissolved purely around the export of slaves, and the idea of "Blackness" became an increasingly legitimate anchor for identity across western Africa,[22,36] new cultural accoutrements were needed — ideally ones legible on both sides of the newly defined Black/non-Black dichotomy. In short, the stage was set for the manilla to worm its way into ubiquity. The bracelets did just that, quickly becoming a *de facto* currency of the slave trade. Over the next three and a half centuries following the first large-scale production of manillas by the Portuguese crown in the early 1500s, manilla production diversified roughly in accordance with the market pressures and imperial politics of the slave trade. The Portuguese controlled most manilla production until the mid-seventeenth century; at this point, following a short transitional period dominated by the French, the English eventually rose to full control of manilla exports. This tripartite timeline is the bedrock of a recent manilla typology developed by the researcher Rolf Denk, which divides manillas into three broad categories (**Figure 3**). Denk's typology is by far the most expansive to date and warrants a brief review.

The first manilla in the typology, which Denk calls the "tacoais" type,[2] is the largest of the three, regularly weighing up to 300 grams.[37] These manillas were commissioned and exported by the Portuguese, but produced mainly in Germany and central Europe, usually using copper ore from the Rhineland.[15,‡] They are the thickest of the three manilla types and are recognizable by their flared but rounded ends. Tacoais-type manillas are generally characterized by extremely high-quality copper, and are thought to have been highly prized among blacksmiths along the West African coast for use as copper ingots. A recent compositional analysis of tacoais manillas by Skowronek et al.[15] suggests that these were the main source of copper used to cast the famous Benin Bronzes during the fifteenth century. †

The next manilla in Denk's typology is known as the "popo" type, possibly in reference to the former slaving port of Grand-Popo, in the modern-day country of Benin. Popo manillas tend to be slightly smaller than tacoais manillas, with the ends tapered rather than flared. Unlike the tacoais, casting seams are often visible on popo manillas, speaking to the general downward trend in the quality of European manillas over time, both in terms of the copper used and the production process. Popos first appear in the archaeological record of West Africa in the mid-seventeenth century, mainly in trading regions dominated by the French. While Denk originally proposed the popo as an exclusively French enterprise (i.e. produced in France, and traded in French West Africa), new compositional analyses suggest that many popo manillas seem to have been produced in Britain.[15,41] More recently,[41] Denk has suggested that the popo might simply represent a short-lived, highly variable transition period between the earlier tacoais type and the later "Birmingham" type — in other words, popo manillas might represent a historical moment, rather than a particular supply chain or sphere of imperial influence.

The final category in Denk's typology, which he calls the "Birmingham type",[2] is perhaps the most easily recognizable, and almost certainly the most abundant in the archaeological record.[42] As their name suggests, these manillas were produced almost exclusively in Britain, mainly in early industrialized cities like Birmingham, Liverpool, Bristol and Swansea.[43] Excavations at a bell foundry in Exeter suggest that production of these manillas was occurring in England as early as 1625,[44] but large-scale production and trade only began in the mid-eighteenth century, following the expansion of English imperial interests and the

† While slavery by definition necessitates the dehumanization of the enslaved, the argument has been made that previous examples of slavery throughout human history have not always required the same sort of absolute social death that characterized the transatlantic slave trade.[14]

‡ Indeed, the term "tacoais" (being the plural — the singular is "tacoal")[2] is a Portuguese word, apparently created from whole cloth, exclusively to describe this type of manilla. The word first appears in Portuguese notary receipts from Antwerp trading houses in the mid-fifteenth century, although it is unclear whether those documents were referring to traditional copper manillas or other, similar objects (Strieder 1932:254).[38] Denk suggests in his 2020 monograph that the word "tacoais" may derive from the root word "taco", meaning "plug" or "heel", perhaps in reference to the bracelet's flared ends.

industrialization of British cities.[45,46] Birmingham-type manillas are the smallest of Denk's three manilla types, and are characterized by flat, dramatically flared ends and highly visible casting seams. Indeed, unlike the tacoais or the popo, many Birmingham-type manillas were too small to be worn as jewelry and too brittle to be used as casting metal, effectively limiting their function to that of specie.[47] Stylistically, the nine manillas in Yale's West Campus storage collections (**Figure 1**) are all "Birminghams".

Figure 3. The Denk manilla typology. The image for the tacoais type has been adapted from photographs by Skowronek;[48] images for the popo and Birmingham types were adapted from photographs by Denk.[2]

What, then, makes Denk's simple typology so valuable, other than as a tool for dating and provenancing individual specimens? There are two important answers to this question. Firstly, the typology is helpful in understanding that manilla production and use directly reflected contemporary imperial power dynamics. This fact is best illustrated by the graph in **Figure 4**, which overlays a rough timeline of Denk's manilla typology with the number of slaves embarked from Africa by Portugal and England during that period. While the French slave trade has not been included in the figure given the uncertainty surrounding the production and general significance of popo manillas, the graph nonetheless tells an interesting story. The disappearance of tacoais-type manillas in the mid-seventeenth century is matched by a precipitous drop in the number of slaves embarked by Portuguese ships.§ Furthermore, Birmingham-type manillas only begin to appear in the early eighteenth century, precisely when the British empire begins to institutionalizes the slave trade.[45] In short, changes in manilla style and production pathways were clearly tethered to the changing imperial power dynamics of the transatlantic slave trade.

Secondly, though, a careful reading of the Denk typology also provides important insights about the end of European empire, and the rise of the modern nation-state framework during the nineteenth and twentieth centuries. This line of reasoning starts with the fact that the Denk typology accounts for change in the Birmingham manilla over the course of the nineteenth century: in Denk's seriation, Birmingham manillas become progressively smaller and more heavily leaded (i.e. lower quality) over time.[2] This progression was closely tied to the rapid industrialization occurring in urban England at the turn of the nineteenth century, particularly in the metalworking industry.[51] On the one hand, this meant that by the time the so-called "Industrial Revolution" hit its acme in the mid-nineteenth century, Britain was pumping out more manillas than ever before. One contemporary source estimates that in 1855, the city of Birmingham alone was producing more than 300 tons of manillas per year for export to West Africa[52] (this translates to as many as 3 million manillas annually, assuming an average weight of about 100 grams per bracelet).**

On the other hand, however, this industrialized proliferation of the manilla also resulted in a progressive loss of its value, from both a monetary and cultural perspective. In order to hit the sorts of output numbers seen in Birmingham in 1855, most manilla producers during this time stopped using brass and bronze and began using a cheaper leaded copper alloy, with lead concentrations of up to 25 percent by weight,[15] and higher levels of antimony.[53] Starting at the beginning of the nineteenth century, this cheapening triggered a race to the bottom. Smaller, lower-quality manillas meant less purchasing power in West Africa; this in turn drove British manilla producers to make even smaller, even cheaper manillas in an effort to maintain profit margins.[52] Indeed, one British source reports that by 1858 in Bonny, in modern-day Nigeria, a Birmingham-type manilla was worth only three pence.[54] That is equivalent to less than five U.S. dollars in 2023.[55]

Parsed carefully, this negative feedback loop in British manilla production can be read as an allegory for the downfall of what the American historian Caroline Elkins and others call "liberal imperialism" — the political philosophy best embodied by Britain but

§ While the Portuguese slave trade roared back to life in the early eighteenth century following the end of the Angolan Wars and the expansion of Brazil, the Portuguese colonies arguably had more autonomy by that time, altering the political power structures governing the trade.[49,50]

occurring throughout modern empires of the Global North, which derives an empire's ruling mandate from its inherent moral and cultural superiority. This is essentially the "white man's burden" argument set forth by the English writer Rudyard Kipling in his famous poem of 1899:[56] the idea that violence against indigenous groups is justified, as long as the end goal is to re-make the victimized populations in the image of Western liberal democracy. As Elkins points out in a recent book, however,[45] liberal imperialism necessarily contained within itself the seeds of its own destruction. By presuming to westernize its foreign subjects, the British and other similar European empires were also implying that those subjects would one day become westernized enough to govern themselves — in short, British liberal imperialism always came with a promise of freedom and self-determination for the oppressed. This promise was not sustainable, for obvious reasons, but it had to be made to continue performing the mental gymnastics necessary to justify the large-scale exploitation of human capital occurring in, say, the sugar plantations of nineteenth century Jamaica.[34]

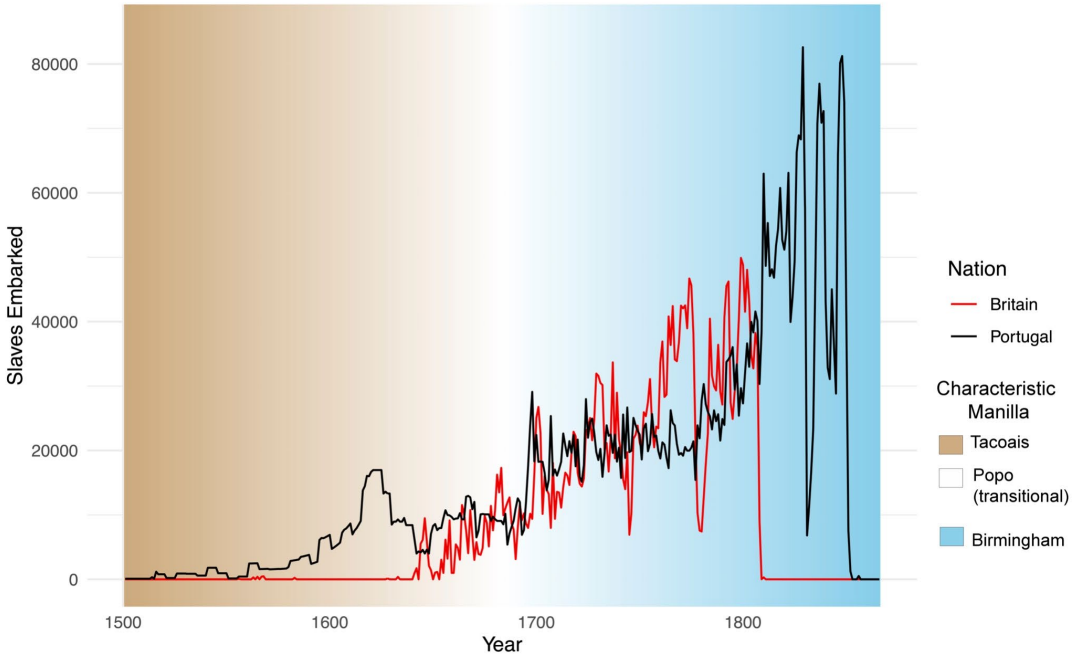

Figure 4. Number of slaves embarked from western Africa by Portugal and Britain between 1514 and 1866, overlaid with the chronological progression of Denk's manilla typology. All data from the Trans-Atlantic Slave Trade Database.[55]

Here is where we return to manillas. In 1807, against a political backdrop dominated by liberal imperialism, Britain outlawed the transatlantic slave trade at the height of its profitability, with an eye towards maintaining moral superiority over its imperial rivals in Europe and its colonized subjects abroad (this of course being one of many complex reasons). [21,**] While this moral gamble arguably paid off for British imperial interests in the medium-term,[30] it also destroyed the lynchpin of the manilla's cultural and economic significance (i.e. as a token of the slave trade), fueling the ensuing race to the bottom and the subsequent consignment of manillas to relative uselessness.

The manilla did not simply disappear, to be sure. In the same way that the transatlantic slave trade continued well into the 1840s,[57] the production and circulation of manillas continued throughout the nineteenth century. The plethora of manillas at a "juju house" in Allabia, in Southern Nigeria, when the building was raided and razed by the British traveling commissioner for the region in 1904 attests to their continued significance among the Andoni people.[59,††] Notably, when use of manillas as currency was outlawed in British colonial Nigeria in 1911, more than 32 million bracelets were redeemed across the country for use as scrap metal, underscoring just how ubiquitous manillas continued to be in West Africa since the end of the slave trade.[16] Setting aside these caveats though, in a sense one might say that the British rendered useless their own mints. Just as the hypocrisy of liberal imperialism spelled the end of the British empire in South Asia and South Africa alike, leaving convoluted nation-state governments and disputed borderlands in its wake,[60] so too did that hypocrisy spell the end of the manilla bracelet as a culturally bivalent form.

** The early nineteenth century was also not the end of British financial involvement in the slave trade, and certainly not the end of manilla production in Britain.[57,58]

†† Indeed, judging by descriptions provided by Apter and Derby, several of the manillas from that building appear to have been of the tacoais type, raising interesting questions about the lifespan of larger, higher-quality manilla bracelets.[59]

How, then, do we understand the story of the manilla, from a material perspective? Or perhaps, more to the point, how can we understand why the story of the manilla is so difficult to understand in the first place. After all, as discussed in the introduction above, it is a story seldom told, and one that sounds slightly different with each telling. Is the bracelet a prestige good and a source of pride (e.g. among its wearers in West Africa)?[5] Or is it a shameful blood money and a reminder of the suffering caused by the slave trade?[20,40] The answer to these questions brings us back to where we began, and to the idea of "metastasizing symbols". Just as a liberal-imperial empire spells out its own demise, metastasizing symbols like the manilla inevitably become stretched too thin by the malevolent processes responsible for their proliferation in the first place. For the manilla this was the slave trade, and European imperial interests in western Africa more broadly. Another example of a metastasizing symbol might be the money cowries harvested in the Maldives and exchanged in West Africa, also as part of the transatlantic slave trade, throughout the sixteenth and seventeenth centuries.[61] Still other examples might include English Premier League football jerseys in postcolonial Africa,[62,63] or the global proliferation of the Timberland work boot, following its adoption by the New York hip hop community of the early 1990s.[64,65] The point is that materially, the production of these items depends on processes of exploitation that are not sustainable.[#] But symbolically, their stories are like energy — neither created nor destroyed, only reshaped and told again, eroded into finer and finer grains of sand, deposited on far-away beaches along the oceans of time until another diagenesis occurs.

METHODS AND PROCEDURES

It is here that we return to those nine metal bracelets, sitting in a storage facility in West Haven. Having considered the manilla as an abstract object, it is now possible to interpret the elemental composition of these individual specimens. The following analysis attempts to do this by comparing X-ray fluorescence (XRF) composition data from the nine YUAG manillas to compositional data derived from eleven previous studies, with the aim of characterizing the YUAG manillas and commenting on their possible origin. Our aim is not to match the manillas to a specific copper ore source or mining site. There are likely too many factors, from combining copper and tin from different deposits to corrosion forming new compounds on the exteriors, for us to make such an identification nondestructively. Instead, archaeological chemist Mark Pollard's concept of "processual provenance" offers a means for us to interpret the compositions of metal objects.[75,76] This framework focuses on chemistry revealing different behaviors in the past, such as choosing bronze recipes based on social factors like economics (e.g., the costs of certain raw materials) or preferences regarding performance characteristics (e.g., the ease of casting, the final appearance). Pollard argued that such factors would differ across space and time and yield a tangible record within the resulting objects.

Compositional data for the nine YUAG manillas were collected, without any alteration of the items, using an Olympus Vanta M-Series portable XRF (pXRF) instrument. A modern pXRF instrument is essentially a state-of-the-art energy-dispersive XRF (EDXRF) system that fits into a small form factor. Quantitative analysis and identification of alloys is one of the major commercial uses of pXRF, a situation that has led to metals having better identifications in scrapyards than in most museums. However, the influence of corrosion on artifacts has been a concern even since the early days of wavelength-dispersive XRF (WDXRF) in archaeological chemistry.[77] Because XRF is essentially a surface technique (i.e., the X-rays penetrate less than a millimeter past the surface of most metals),[78] pXRF measurements have the potential to become skewed by products of corrosion. Bronze, as a non-ferrous metal, does not rust like iron. As shown in Figure 1, several of the YUAG manillas exhibit a tarnished brown color of simple oxidation, while others exhibit a green patina indicative of copper hydroxides, chlorides, and carbonates, among other related compounds.

For more than a decade, there have been studies with and tests of pXRF measurements of archaeological copper alloys,[79–87] including scrutiny by specialists in archaeological metallurgy.[88–90] Given that reliable and nondestructive measurements are possible using EDXRF,[91] there is little reason for pXRF to be any worse in this respect. Many of the assessments have been cautiously optimistic, especially when concentrating on the major and minor elements such as Ni, Zn, Sn, Sb, and Pb.[90,92,93] For example, Roxburgh et al. discerned pre-Roman (high Sn) and Roman (high Zn) bronze broaches in the Netherlands and concluded that their data were comparable to previous studies.[94] Some have been more skeptical in their assessments,[85] with one having gone so far as to call pXRF a "curse" for archaeometallurgy due to its popularity and uncritical use.[95] Our use here, though, should not be regarded as uncritical but instead as informed by those studies that have tested and implemented effective applications of pXRF.

[#] In the case of English football, as global broadcast rights become increasingly expensive (often selling for billions of dollars)[66] and neo-feudal autocracy becomes the only viable football governance structure (consider, e.g., the rise of figures like Gianni Infantino, or Sheikh Mansour),[67] the existence of the Premier League itself is becoming ever more precarious (Bosher 2023; Brannagan et al. 2022).[68,69] In the case of Timberland shoes (among other symbols of early New York hip hop),[70] the commodification of hip hop by global capital,[71] combined with the disappearance of large swaths of its New York City homeland via processes of urban gentrification,[72] has effectively diluted the brand.[73,74]

Source	Method	Number of manillas
YUAG manillas	pXRF (Olympus Vanta handheld)	9
Caley and Shank 1966	Solution analysis (see Caley 1964:81-97 for detailed procedure)	2
Craddock 1985	AAS§§ (Perkin Elmer series 306)	34
Craddock et al. 1997	ICP-AES*** (machine unspecified)	2
Craddock and Hook 1995	ICP-OES (machine unspecified)	15
Denk 2020	pXRF (Niton XL3t GOLDD+)	10
Denk et al. 2020	pXRF (Niton XL3t GOLDD+)	3
Denk et al. 2019	pXRF (Niton XL3t GOLDD+)	1
Kuntz et al. 2002	Energy dispersive XRF (Kevex Spectrace Quanx spectrometer)	17
Riederer 2013	AAS (machine unspecified)	1
Skowroneck et al. 2023	ICP-MS (Thermo Fisher Scientific ELEMENT XR)	67
Werner 1978	ICP-OES (see Riederer 2013:109 for procedure)	1

Table 1. Data used in this study. The analysis included composition data from a total of 162 manillas.

One recommendation to come out of previous assessments is to measure larger areas and take multiple measurements.[86,90] Additionally, the resulting pXRF data may reveal which spots exhibit more or less corrosion. Detecting large amounts of chlorine, for example, can reveal that a measurement was taken on an especially corroded spot and that it should be excluded. Five 20-second pXRF measurements were taken of each YUAG manilla on areas that appeared least corroded. An effort was made to spread the measurements out across the entirety of each bracelet, in case of any heterogeneity in corrosion. Furthermore, when it was immediately clear during testing that a measurement was mostly describing corrosion products (i.e. extremely high levels of light elements, etc.), that measurement was dropped and re-taken. The measurements were calibrated for accuracy using a set of 12 certified standards designed for historical copper alloys and produced by MBH Analytical.[96] In order to compare the nine YUAG bracelets to other manillas of known provenance, a database of additional composition data was assembled from the peer-reviewed literature, following a survey of search engines including Proquest, Google Scholar, JSTOR and others, as well as a survey of several catalogs from museums across England and Germany. The resulting "database" (summarized in **Table 1**) included a total of 153 manillas, from 11 different publications. For the purposes of the following analysis, most specimens from the database were assigned to one of the three categories from the Denk typology (i.e. tacoais, popo or Birmingham). Several of the 153 manillas from the database could not be classified using the Denk typology, however. For this reason, three categories were added to Denk's typology prior to my own analysis. These were "Birmingham-mkporo," "King" and "pre-contact". "Birmingham-mkporo" is Denk's shorthand for what he and others believe to be very early Birmingam-type bracelets, probably dating to the late seventeenth through early eighteenth centuries.[2,97] "Mkporo" manillas (named for a term used loosely throughout several language groups in eastern West Africa to describe manilla bracelets, but also money more generally)[47] are similar in shape to other Birmingham types, but are identifiable mainly by their larger size and higher copper content.[2] While the provenance notes attached to several mkporo manillas in the British Museum collections suggest that they may have been produced in Nigeria rather than Britain (i.e. that mkporos may be purely indigenous to West Africa), the category nonetheless remains useful for analysis. The "King" manilla category was used to describe four manillas analyzed by Craddock in 1985,[98] as well as Kuntz et al. in 2002.[43] The term, used by the authors of both studies, appears elsewhere in the literature and in common usage to describe any manilla produced in West Africa (rather than Europe) with a diameter greater than about 20 cm.[2,16,43] The four King manillas included in this study are currently in the British Museum collections, and are believed by Craddock to have been produced in Bende, Nigeria, in the late nineteenth century.[98]

§§ Atomic absorption spectroscopy, i.e. inferring the abundance of specific elements by measuring which wavelengths of light are absorbed by a sample.
*** ICP here refers to "inductively coupled plasma" spectroscopy. Varieties include ICP-AES (atomic emission spectroscopy), ICP-OES (optical emission spectroscopy) and ICP-MS (mass spectroscopy). All three methods use a plasma to ionize the elements in a sample, before measuring their abundances via spectroscopy.

The final new category, "pre-contact", was used to describe a single manilla excavated during the 1960s from the archaeological site of Igbo-Ukwu, in southeastern Nigeria.[42] The specimen, also currently housed in the British Museum (object number Af1956,15.4), is roughly the size and shape of a Birmingham-type manilla, but is knotted in the middle, and is more than 98 percent copper, supposedly weighing more than a kilogram.[98] Excavation reports list it as coming from stratigraphic layers with radiocarbon dates calibrated to the tenth century (hence the designation "pre-contact" — in other words, before the arrival of the Portuguese on the West African coast), raising the possibility that this is an example of an ancestral form, from before the nexus of manilla production moved to Western Europe in the 1500s. The remarkable provenance of the Igbo-Ukwu manilla is called into question, however, by the bracelet's listing in the British Museum catalog, where it is entered as having been given as a gift (presumably to the excavating archaeologists at Igbo-Ukwu, based on its description in the excavation reports)[42] by Frank W. Carpenter, a local British district commissioner. While its inclusion in Shaw's 1970 excavation report makes it seem as though it may still have come from tenth century contexts, it was likely not formally excavated. Regardless of this confusion, for the purpose of the below analysis, the "pre-contact" manilla was still stylistically distinct enough from all the other specimens to be given its own category.

The studies included in the database span several decades, with the earliest one published in 1966 and the most recent in 2023.[15,99] The studies also encompass a wide variety of methods, with varying degrees of error and uncertainty — even within individual publications. For example, Craddock's emission spectroscopic data exhibited, as would be expected for any analytical technique, low measurement error (approximately ±1%) for all major elements, but as much as ±20% for trace elements.[75,100] To this end, only specimens with weight percentages listed for key major elements — copper, lead, tin, antimony and zinc — were included in the following statistical analyses (i.e., 139 of the total 153 gathered from the previous studies). Of course, our data collected from the nine YUAG manillas is not immune to uncertainty either, as we note above. However, based on previous tests of pXRF on archaeological copper alloys, the major elements also yielded the most reliable results. Nevertheless, the data included in this study can be thought of as semi-quantitative and do not precisely reflect either the ores or recipes used by the craftspeople involved. Corrosion products, even when not evident by eye, are still present, given the detection of a few percent sulfur for each manilla. We employ our data as percentages and process them using statistical methods, but the final results are perhaps best interpreted qualitatively (e.g. "these two bracelets have very similar compositions" versus "these two bracelets have less similar compositions"). Accordingly, our approach is similar to that of Martinón-Torres and colleagues, who identified different casting batches of bronze arrows among warriors of Emperor Qin Shi Huang's Terracotta Army.[88]

RESULTS

Figure 5 shows the composition data collected from the nine YUAG manillas (see also **Table 2**). Immediately, a preliminary survey of the results makes clear that all nine are cast from leaded copper alloy, rather than bronze, as many earlier Birmingham-type manillas were, particularly during the late eighteenth century.[48] In any case, they are certainly not iron, as the YUAG collections database suggests.

In order to properly understand the pXRF data from the YUAG manillas, however, they must be compared to composition data from the other manillas in the database. When all the data are visualized together — firstly in a principal component analysis (PCA; **Figure 6**), and secondly in a ternary diagram for lead, tin and zinc concentrations (**Figure 7**) — a few points become apparent. Firstly, if we are to deploy the categories of the Denk typology, then the PCA in **Figure 6** would suggest that the Birmingham-type manilla represented a clear break in supply chains and production processes. Principal component 1 in the PCA (PC1, i.e. the X axis in **Figure 6**) serves mainly to divide Birmingham- from non-Birmingham-types, indicating that the composition of most Birmingham-type manillas included in this analysis was profoundly different from the compositions of both the tacoais- and popo-type manillas, which were relatively similar to each other by comparison (save for about seven popo manillas, which fall in a sort of transition range between the tacoais and Birmingham samples). This divide in the PCA could also be driven by the spread of the manilla categories across the different data sources — notably, the composition data for a majority of the tacoais manillas in the dataset come from a recent study by Skowronek et al., and most of them come from the same source (a shipwreck off the coast of San Sebastian, in Spain).[15] But the fact that these San Sebastian tacoais cluster so far from any of the Birmingham-type manillas (including those also sampled by Skowronek et al.)[15] is nonetheless meaningful. Additionally, the fact that a strong Birmingham-tacoais divide is also visible in the ternary diagram in **Figure 7** suggests that it is not simply due to the transformations involved in mapping out the first two principal components.

Secondly, the initial visualization of the entire dataset in **Figures 6** and **7** also underscores the divide between Birmingham "mkporos" and other Birmingham-type manillas. In the PCA, the two categories are separated out mostly along PC1, suggesting a large amount of variation between them. In the ternary diagram, the two groups appear to be slightly more closely related, but the

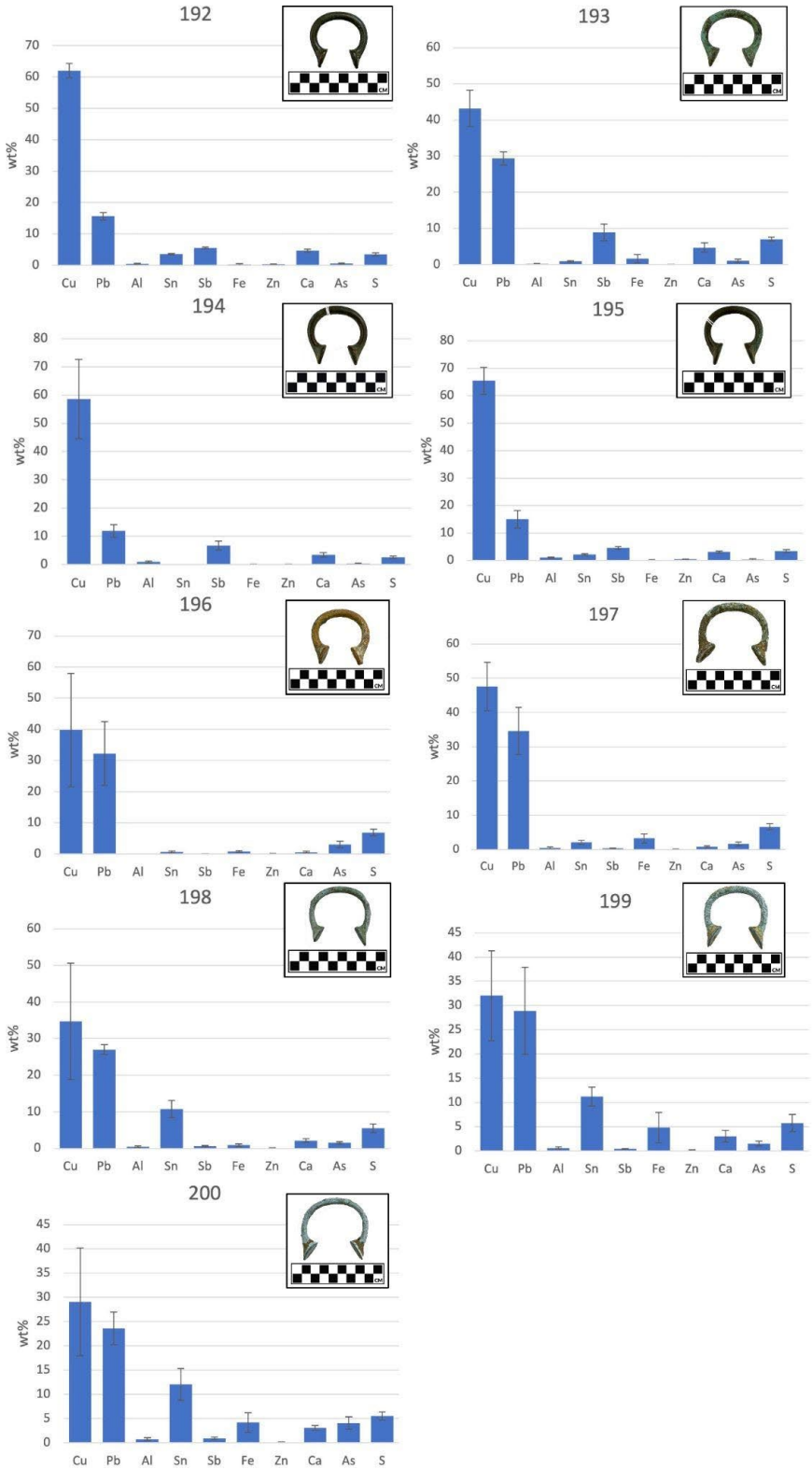

Figure 5. Average composition of the nine YUAG manillas, calculated from five pXRF readings for each bracelet. Error bars show one standard deviation.

mkporo manillas display much greater variation in their composition and tend to show lower levels of lead. The "pre-contact" manilla from Igbo-Ukwu, meanwhile, clusters suspiciously closely to several mkporo-type manillas on both the PCA and the ternary diagram, further calling into question its tenth century provenance. Regardless of its age, though, if the "pre-contact"

manilla was indeed produced in West Africa, then its similarity to the mkporos could instead indicate that the "mkporo" designation indicates production within West Africa. This is supported by the similarity between the mkporos and the one King manilla included in the statistical analyses: since the King manilla is known to have been produced in southern Nigeria near the end of the nineteenth century, the fact that it clusters with the mkporos lends strength to the hypothesis that mkporo manillas may have been produced in West Africa as well. Either way, these initial results suggest that "mkporos" deserve their own category in the Denk typology. Indeed, on this note, the "Kongo manillas" discussed above — typified by large, thick bodies and undecorated ends (**Figure 2**) — may also represent an important new category. Or, at the very least, they seem to be worth investigating via further composition analysis. However, they also appear to split into two distinct groups along the right hand side of the ternary diagram, with accession numbers 192 through 195 (see **Figure 1** above for reference) clustering in the bottom-right corner, and accession numbers 196 to 200 exhibiting much greater variation in lead concentration. These groups are also visible along PC2 in the PCA: when nonparametric density contours are drawn around the YUAG manillas on a two-dimensional scatter plot of the first two principal components, the two clusters separate out at about the 50 percent interval, indicating a noteworthy (if not exactly clear-cut) division. From a common-sense perspective, these two groupings within the composition data also make sense visually. Specimens 192-195 are smaller and slightly more circular, with less variation in size (average diameter = 6.16 cm; $\sigma = 0.134$), while specimens 196-200 are larger, more elliptical, and more varied in their shape and size (average diameter = 6.95 cm; $\sigma = 0.576$). Specimens 196-200 are also more heavily corroded, raising the possibility of a different provenance, or at least a different use-history.

Several attempts have already been made by European authors at categorizing different types of Birmingham-style manillas.[52,54] One such example, a typology assembled by the Swedish amateur ethnographer Sven-Olof Johansson, might be useful here.[47] YUAG specimens 192-195 are very visually similar to what Johansson calls "okpohos", a small currency manilla used widely throughout British colonial West Africa. Specimens 196-200, meanwhile, are much closer to what Johansson calls "onoudus", an oval-shaped bracelet most common in modern-day Cross-River state, in southern Nigeria.

Interestingly, when the PCA plot is color-coded by origin (**Figure 6**), the okpoho group (specimens 192-195) cluster quite closely with several mid-nineteenth century Birmingham manillas from the wreck of a British ship off the coast of the Scilly Islands in 1843 (the group falls within the 60 percent interval when the entire dataset is used to generate nonparametric density contours).††† The onoudu group, however (YUAG specimens 196-200), do not seem to cluster within any of the specimens from previous studies, and indeed exhibit a much larger amount of diversity among themselves. While this difference could be due to their worse preservation (as mentioned above, they are clearly more corroded than the manillas in the okpoho group), the slight variety in their shape and size suggest that it may also be due to different production histories.

With these general observations in mind, it is possible to return to the nine YUAG manillas. They cluster with the other Birmingham manillas in the PCA, the ternary plot and the bar graphs in **Figure 8**, as expected based on their shape and size — within the parameters of the Denk typology, they are definitely "Birmingham" manillas.

DISCUSSION AND CONCLUSIONS

Following the initial analysis described above, in the interest of identifying a precise production location for the nine YUAG manillas, a spatial analysis was also undertaken. To start, all manillas with known provenance were plotted as points in ArcGIS Pro, along with their lead and zinc concentrations. The ArcGIS inverse distance weighting (IDW) function was then used to interpolate likely lead and zinc concentrations for hypothetical manillas produced in those areas (i.e. "landscape maps" for lead and zinc). While it should not be assumed that there is any sort of predictable correlation between production location and manilla composition over vast distances (it would not be possible, for instance, to interpolate expected lead concentrations for manillas in Senegal based only on those in Bende), an interpolation can at least be used to visualize places where the sampled manillas were most similar to those from the YUAG. Several IDW models were tested; a second-order polynomial, with a cell size of 10 km^2, generated the least discrepancy between known and interpolated concentration values for the manillas with known production locations (the discrepancy between actual and predicted values for this model was 4.02 percent for lead, and 0.680 percent for zinc).

Figure 9 shows the result of the IDW analysis: the only spot where the interpolated values for both lead and zinc match the observed range of concentrations for those elements in the YUAG manillas is in northwest England, near Liverpool, where the *Douro* is thought to have sourced its manillas before sinking in 1843.[101] This makes sense — as mentioned above, YUAG specimens 192-195 cluster with the manillas from the *Douro* wreck in the PCA plot (particularly specimen 193, whose composition

††† From the perspective of PC1 on the PCA plot, the okpoho group (specimens 192-195) also appears to cluster quite closely with manillas recovered from a much earlier wreck (from 1717) off the coast of Cape Cod, in Massachusetts. But when the raw composition data is considered — e.g. in the lower bar graph in **Figure 10** — the manillas from the Cape Cod wreck are revealed to be quite different from their YUAG counterparts.

matches the average element concentrations in the *Douro* manillas almost exactly). The *Douro* sank off the coast of the Scilly Islands on the night of Thursday, January 26, 1843. According to contemporary newspaper reports, the ship was sailing from its home port of Liverpool to Porto, Portugal, apparently as the first leg on a longer voyage to West Africa.[101,102] The wreck was discovered by amateur divers from the Scilly Islands in 1972, when they reported finding hundreds of manillas.[15] Many of these ended up in private collections across England;[103,104] it is not an impossible leap to imagine that some of the manillas in the YUAG collections could even have come from this shipwreck.

YUAG Accession Number	Average wt% (standard deviation in parenthesis)									
	Cu	Pb	Al	Sn	Sb	Fe	Zn	Ca	As	S
2010.6.192	62.1 (2.3)	15.7 (1.2)	0.5 (0.2)	3.6 (0.2)	5.6 (0.2)	0.3 (0.2)	0.4 (0.02)	4.7 (0.5)	0.6 (0.1)	3.5 (0.5)
2010.6.193	43.2 (5.0)	29.4 (1.8)	0.2 (0.04)	0.9 (0.2)	8.9 (2.3)	1.6 (1.1)	0.1 (0.02)	4.7 (1.3)	1.1 (0.4)	7.0 (0.5)
2010.6.194	58.6 (14.1)	11.9 (2.3)	0.9 (0.4)	0.04 (0.01)	6.7 (1.6)	0.1 (0.02)	0.1 (0.03)	3.5 (0.8)	0.4 (0.2)	2.5 (0.5)
2010.6.195	65.4 (4.9)	15.0 (3.2)	1.0 (0.1)	2.2 (0.3)	4.6 (0.5)	0.2 (0.1)	0.5 (0.03)	3.1 (0.4)	0.3 (0.2)	3.4 (0.5)
2010.6.196	39.8 (18.2)	32.3 (10.2)	Not detected	0.7 (0.2)	0.1 (0.02)	0.8 (0.3)	0.1 (0.1)	0.6 (0.2)	3.1 (1.0)	6.9 (1.1)
2010.6.197	47.6 (7.1)	34.6 (6.9)	0.5 (0.4)	2.1 (0.6)	0.4 (0.1)	3.3 (1.3)	0.1 (0.02)	0.8 (0.3)	1.6 (0.6)	6.7 (0.9)
2010.6.198	34.7 (15.9)	27.0 (1.3)	0.5 (0.2)	10.7 (2.4)	0.6 (0.2)	0.9 (0.4)	0.1 (0.1)	2.1 (0.5)	1.5 (0.3)	5.5 (1.2)
2010.6.199	32.1 (9.3)	28.9 (9.0)	0.6 (0.2)	11.2 (2.0)	0.4 (0.1)	4.8 (3.2)	0.1 (0.1)	3.0 (1.2)	1.5 (0.5)	5.8 (1.8)
2010.6.200	29.1 (11.1)	23.6 (3.4)	0.7 (0.3)	12.0 (3.3)	0.9 (0.3)	4.2 (2.0)	0.1 (0.03)	3.1 (0.5)	4.1 (1.2)	5.5 (0.8)

Table 2. PXRF data for the nine YUAG manillas. Listed weight percents are averages of the five measurements taken for each bracelet.

The map in **Figure 9** is not meant to be exact, of course. Precise sourcing of manilla production locations within England is difficult, and the coverage provided by the database is quite thin for an IDW analysis (fewer than 70 of the 153 manillas had known production locations, and the accuracy of interpolated values generally tends to decrease with fewer or less well-distributed reference points). A more holistic sourcing attempt would arguably also involve lead isotope analysis, a destructive sampling

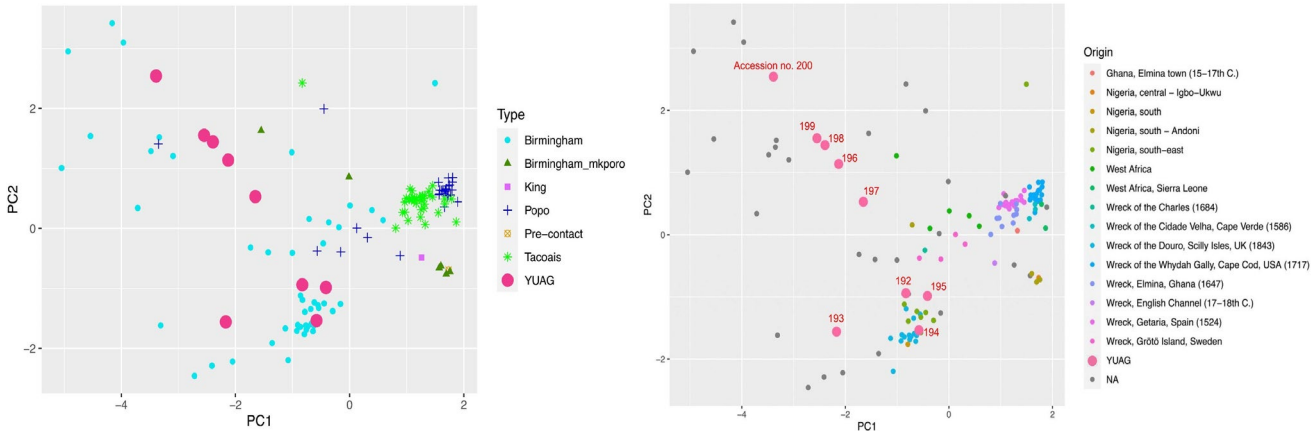

Figure 6. Plot of the first two principal components from a PCA of composition data from the nine YUAG manillas and 130 others. The PCA included weight percentages for As, Cu, Pb, Sb, Sn and Zn. Left: points coded by type; right: same PCA plot, but with points coded by provenance. The YUAG manillas in the bottom plot are labeled with their accession number.

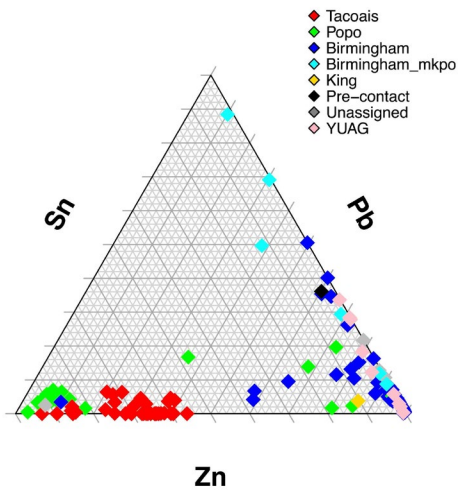

Figure 7. Ternary diagram relating concentrations of Pb, Sn and Zn in the nine YUAG manillas and 130 others. These three elements were on average the most abundant across all 162 specimens (other than copper).

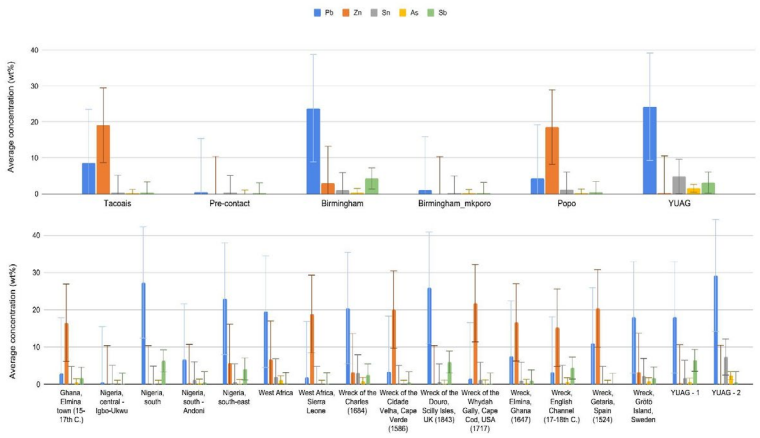

Figure 8. Bar graphs comparing the average composition of the nine YUAG manillas to manillas from previous studies. Top: manillas grouped by typology; bottom: grouped by provenance. Error bars show one standard deviation. The "YUAG 1" and "YUAG 2" groups in the bottom plot refer to the two groups visible along PC2 in the PCA plot in Figure 8 above (YUAG 1 = specimens 192-195; YUAG 2 = specimens 196-200).

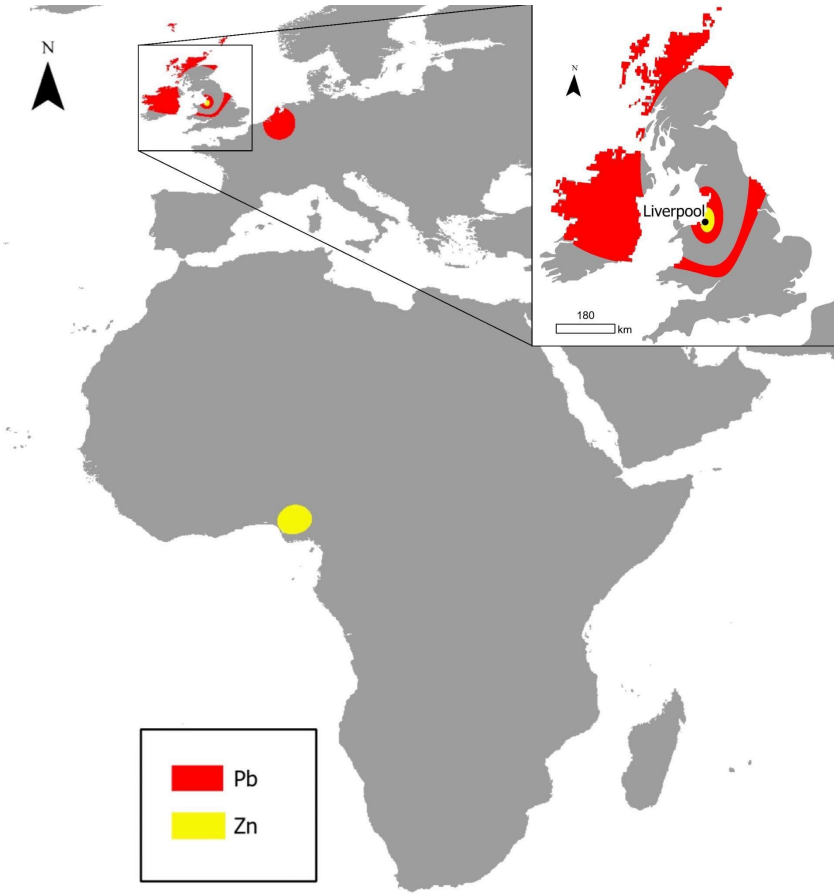

Figure 9. Places where the metal used in manilla production was likely to have had compositions falling within the range exhibited by the nine YUAG manillas. Pb and Zn maps were interpolated based on manillas from previous studies with known Pb and Zn concentrations and known production locations (n = 68), using inverse distance weighting (IDW), with a second order polynomial.

technique not permitted by the YUAG's collection policies. All lead isotopes except ^{204}Pb are radiogenic; the fractionation of lead isotopes in a sample of archaeological metal (usually measured via mass spectrometry of lead sulfide, precipitated from a small amount of swarf) can thus describe the geologic age of the original ore. By comparing lead isotope ratios in the manillas to lead

isotope ratios in British ore deposits known to have been used during the nineteenth century, one could in theory pinpoint the geographic source of the metal used to cast the bracelets and, from there, use primary sources to reconstruct a geography of their production. Skowronek et al. recently employed this method for a large collection of manillas, including several Birmingham-type bracelets with known provenance.[15] A comparison between those lead isotope data and data from the YUAG manillas could be particularly fruitful.

Nonetheless, when the IDW analysis in **Figure 9** above is taken together with the stylistic attributes and weight percentage concentrations of YUAG specimens 192-195, the map is at least a useful tool in envisioning a possible provenance for some of the YUAG's manilla bracelets.

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REFERENCES

1. Sun, M. INSIGHT: Discovering Yale's West Campus. *Yale Daily News* (2019). *https://yaledailynews.com/blog/2019/11/22/insight-discovering-yales-west-campus/*.
2. Denk, R. *The West African Manilla Currency: Research and Securing of Evidence from 1439-2019*. (Tredition, Rüsselsheim, 2020).
3. Derefaka, A. A. & Anozie, F. N. Economic and Cultural Prehistory of the Niger Delta. *Afr. Arts* **35**, 78–96 (2002). *https://doi.org/10.1162/afar.2002.35.1.78*.
4. YUAG (Yale University Art Gallery). *Yale University Art Gallery Collections* (2023). *https://artgallery.yale.edu/collection*.
5. Adelekan, A. Manchester Museum Interviews. *Manillas*. 2007. https://www.youtube.com/watch?v=Spbu7H-4Lsg.
6. Kopytoff, I. The Cultural Biography of Things: Commoditization as Process. in *The Social Life of Things: Commodities in Cultural Perspective* (ed. Appadurai, A.) (Cambridge University Press, 1986). *https://doi.org/10.1017/CBO9780511819582*.
7. Deetz, J. History and Archaeological Theory: Walter Taylor Revisited. *Am. Antiq.* **53**, 13–22 (1988). *https://doi.org/10.2307/281151*.
8. Brásio, A. *Monumenta missionaria africana. Africa ocidental.* (Lisboa, Agência Geral do Ultramar, Divisão de Publicações e Biblioteca, 1958).
9. Ringquist, J. Kongo Iron: Symbolic Power, Superior Technology and Slave Wisdom. *Afr. Diaspora Archaeol. Newsl.* **11**, (2008). *https://hdl.handle.net/20.500.14394/996*.
10. Herbert, E. W. Manillas, Neptunes, Rods, and Wire: The Maritime Trade from the Discoveries to c. 1800. in *Red Gold of Africa: Copper in Precolonial History and Culture* 123–154 (University of Wisconsin Press, 1984).
11. Newitt, M. *The Portuguese in West Africa, 1415–1670: A Documentary History*. (Cambridge University Press, 2010).
12. Wilderson III, F. B. Cinematic Unrest: Bush Mama and the Black Liberation Army. in *Red, White & Black* (Duke University Press, North Carolina, 2010).
13. Bateson, G. Culture Contact and Schismogenesis. *Man* **35**, 178–183 (1935). *https://doi.org/10.2307/2789408*.
14. Graeber, D. & Wengrow, D. *The Dawn of Everything: A New History of Humanity*. (Farrar, Straus and Giroux, 2021).
15. Skowronek, T. B. *et al.* German brass for Benin Bronzes: Geochemical analysis insights into the early Atlantic trade. *PLOS ONE* **18**, e0283415 (2023). *https://doi.org/10.1371/journal.pone.0283415*.
16. Alpern, S. B. What Africans Got for Their Slaves: A Master List of European Trade Goods. *Hist. Afr.* **22**, 5–43 (1995). *https://doi.org/10.2307/3171906*.
17. Hamann, N. L. Forging an Atlantic World: An Historical Archaeological Investigation of African-European Trade in Metalwares. (The University of West Florida, Florida, 2003).
18. Jackson, R. M. *Journal of a Voyage to Bonny River on the West Coast of Africa in the Ship Kingston from Liverpool: Peter Jackson, Commander*. (Garden City Press, 1834).
19. Craddock, P. T. *et al.* Metal Sources and the Bronzes from Igbo-Ukwu, Nigeria. *J. Field Archaeol.* **24**, 405–429 (1997). *https://www.jstor.org/stable/530674*.
20. Alberge, D. Slavery Traders Tried to Cheat Africans with Impure Cornish Copper, Says Study. *The Guardian* (2022). *https://www.theguardian.com/world/2022/oct/03/slavery-traders-tried-to-cheat-africans-with-impure-cornish-copper-says-study*.
21. Radburn, N. *Traders in Men: Merchants and the Transformation of the Transatlantic Slave Trade*. (Yale University Press, 2023).
22. French, H. W. *Born in Blackness: Africa, Africans, and the Making of the Modern World, 1471 to the Second World War*. (Liveright Publishing Corporation, A Division of W. W. Norton & Company, New York, 2021).
23. Cartwright, M. The Portuguese Colonization of São Tomé and Principe. *World History Encyclopedia* (2021). *https://www.worldhistory.org/article/1763/the-portuguese-colonization-of-sao-tome-and-princi/*.
24. Cartwright, M. The Portuguese Colonization of Cape Verde. *World History Encyclopedia* (2021). *https://www.worldhistory.org/article/1762/the-portuguese-colonization-of-cape-verde/*.

25. Austen, R. A. & Smith, W. D. Private Tooth Decay as Public Economic Virtue: The Slave-Sugar Triangle, Consumerism, and European Industrialization. *Soc. Sci. Hist.* **14**, 95–115 (1990). *https://doi.org/10.2307/1171366*.

26. Mintz, S. W. Time, Sugar, and Sweetness. in *Food and Culture* (eds. Counihan, C., Van Esterik, P. & Julier, A.) (Routledge, 2017).

27. Eltis, D. A Brief Overview of the Trans-Atlantic Slave Trade. *Slave Voyages* (2007). *https://www.slavevoyages.org/voyage/essays#interpretation/overview-trans-atlantic-slave-trade/introduction/0/en/*.

28. Patterson, O. *Slavery and Social Death.* (Harvard University Press, 1982).

29. Donington, K. *The Bonds of Family: Slavery, Commerce and Culture in the British Atlantic World.* (Manchester University Press, 2019).

30. Everill, B. *Not Made by Slaves: Ethical Capitalism in the Age of Abolition.* (Harvard University Press, 2020). *https://doi.org/10.4159/9780674250093*.

31. Lovejoy, P. E. The Impact of the Atlantic Slave Trade on Africa: A Review of the Literature. *J. Afr. Hist.* **30**, 365–394 (1989). *https://www.jstor.org/stable/182914*.

32. Nunn, N. The Long-Term Effects of Africa's Slave Trades. *Q. J. Econ.* **123**, 139–176 (2008). *https://www.jstor.org/stable/25098896*.

33. Radburn, N. Keeping "the wheel in motion": Trans-Atlantic Credit Terms, Slave Prices, and the Geography of Slavery in the British Americas, 1755–1807. *J. Econ. Hist.* **75**, 660–689 (2015). *https://doi.org/10.1017/S0022050715001084*.

34. Patterson, O. *The Sociology of Slavery: Black Society in Jamaica, 1655-1838*. (John Wiley & Sons, 2022).

35. Bostoen, K. & Brinkman, I (eds.). *The Kongo Kingdom: The Origins, Dynamics and Cosmopolitan Culture of an African Polity*. (Cambridge University Press, 2018).

36. White, A. *Revolutionary Things: Material Culture and Politics in the Late Eighteenth-Century Atlantic World.* (Yale University Press, 2023).

37. Werner, O. Westafrikanische Manillas aus deutschen Metallhütten, Verwertung von Kupferschrott im 15. und 16. Jarhundert. *Erzmetall* **29**, 447–453 (1976).

38. Strieder, J. Negerkunst von Benin und deutsches Metallexportgewerbe im 15. und 16. Jahrhundert. *Z. Für Ethnol.* **64**, 249–259 (1932). *https://www.jstor.org/stable/25839390*.

39. Marshall, A. This Art Was Looted 123 Years Ago. Will It Ever Be Returned? *The New York Times* (2020). *https://www.nytimes.com/2020/01/23/arts/design/benin-bronzes.html*.

40. Restitution Study Group. About the Restitution Study Group (2023). *https://rsgincorp.org/*.

41. Denk, R., Behrendt, S., Paz, B. & Rosner, M. Archaeometric Investigations of Portuguese Tacoais Manillas. *Baessler-Arch.* **66**, 99–110 (2020).

42. Shaw, T. *Igbo-Ukwu: An Account of Archaeological Discoveries in Eastern Nigeria.* vol. 1 (Northwestern University Press, Ibadan, Nigeria, 1970).

43. Kuntz, M., Ferguson, J., Iduma, V., Kuzava, R. & Benvenuto, M. Chemical Compositions of African Trade Bracelets (Manillas) via Energy Dispersive X-Ray Fluorescence. *Am. J. Undergrad. Res.* **1**, (2002). *https://doi.org/10.33697/ajur.2002.008*.

44. Dungworth, D. *Sixteenth and Seventeenth Century Bronze Casting from Cowick Street, Exeter, Devon*. 1–8 (2002). *https://archaeologydataservice.ac.uk/archiveDS/archiveDownload?t=arch-4637-1/dissemination/pdf/englishh2-370292_1.pdf*.

45. Elkins, C. *Legacy of Violence: A History of the British Empire.* (Knopf, New York, 2023).

46. Jones, P. M. *Industrial Enlightenment: Science, Technology and Culture in Birmingham and the West Midlands 1760-1820*. (Manchester University Press, Manchester, United Kingdom, 2013).

47. Johansson, S.-O. *Nigerian Currencies; Manillas Cowries and Others.* (Alfa-Tryck, Norrköping, 1967).

48. Skowronek, T. Geochemische Charakterisierung von Buntmetallbarren und Halbfabrikaten der Frühneuzeit zur Beantwortung historischer Fragestellungen. (Ruhr-Universität Bochum, Germany, 2021).

49. Altic, M. Missionary Cartography of the Amazon after the Treaty of Madrid (1750): The Jesuit Contribution to the Demarcation of Imperial Frontiers. *Terrae Incogn.* **46**, 69–85 (2014). *https://doi.org/10.1179/0082288414Z.00000000032*.

50. Domingues da Silva, D. B. The Atlantic Slave Trade from Angola: A Port-by-Port Estimate of Slaves Embarked, 1701–1867. *Int. J. Afr. Hist. Stud.* **46**, 105–122 (2013). *https://www.jstor.org/stable/24393098*.

51. Berg, M. *Markets and Manufacture in Early Industrial Europe.* (Routledge, 1991).

52. Blaauw, W. H. Proceedings at the Meeting of the Archaeological Institute. *Archaeol. J.* **12**, 178–203 (1855). *https://doi.org/10.1080/00665983.1855.10850989*.

53. Skowronek, T. B. Personal communication. (2023).

54. Hutchinson, T. J. *Impressions of Western Africa: With Remarks on the Diseases of the Climate and a Report on the Peculiarities of Trade Up the Rivers in the Bight of Biafra.* (Longman, Brown, Green, Longmans, & Roberts, 1858).

55. Nye, E. W. Pounds Sterling to Dollars: Historical Conversion of Currency. *University of Wyoming Numimage* https://www.uwyo.edu/numimage/currency.htm (2023).

56. Brantlinger, P. Kipling's 'The White Man's Burden' and Its Afterlives. *Engl. Lit. Transit. 1880-1920* **50**, 172–191 (2007). *https://muse.jhu.edu/pub/74/article/209518*.

57. Marques, L. *The United States and the Transatlantic Slave Trade to the Americas, 1776-1867.* (Yale University Press, 2016).

58. Sherwood, M. The British Illegal Slave Trade, 1808-1830. *J. Eighteenth-Century Stud.* **31**, 293–305 (2008). *https://doi.org/10.1111/j.1754-0208.2008.00105.x*.

59. Apter, A. & Derby, L. *Activating the Past: History and Memory in the Black Atlantic World*. (Cambridge Scholars Publishing, 2009).

60. Bhat, S. A. The Kashmir conflict and human rights. *Race Cl.* **61**, 77–86 (2019). *https://doi.org/10.1177/0306396819850988*.

61. Wintjes, J. A Cowrie's Life: The São Bento and Transoceanic Trade in the Sixteenth Century. *East. Afr. Lit. Cult. Stud.* **6**, 237–257 (2020). *https://doi.org/10.1080/23277408.2020.1826849*.

62. Waliaula, S. & Okong'o, J. The COVID-19 Pandemic and the social life of English Premier League Football Fandom in Eldoret, Kenya. in *COVID-19 and the Soccer World* (ed. Bandyopadhyay, K.) (Routledge, 2022).

63. Tsaaior, J. T. Football as social unconcious or the cultural logic of late imperialism in postcolonial Nigeria. in *Popular Culture in Africa: The Episteme of the Everyday* (eds. Newell, S. & Okome, O.) 275–288 (Routledge, 2013).

64. Graham, J., Toler, T. S., Ferguson, N. S., Alfonso Arias, R. & Avila, A. Started from the Bottom and Now We're Here?: Hip-hop Culture and its Impact. in *Handbook of Research on Ethnic and Intra-cultural Marketing* (eds. H, B., Glen, P, S., Camille & Rebeca, P.) 118–135 (Edward Elgar Publishing, UK, 2022).

65. Morgan, M. & Bennett, D. Hip-Hop & the Global Imprint of a Black Cultural Form. *Daedalus* **140**, 176–196 (2011). *https://doi.org/10.1162/DAED_a_00086*.

66. Mackey, E. How Premier League TV rights work and how they impact your costs and subscriptions. *The Athletic* (2023). *https://theathletic.com/4240951/2023/08/25/premier-league-tv-rights-how-work-cost/*.

67. Parnell, D., Rookwood, J., Bond, A., Widdop, P. & Ludvigsen, J. A. L. 'It's a whole new ball game': thirty years of the English Premier League. *Soccer Soc.* **23**, 329–333 (2022). *https://doi.org/10.1080/14660970.2022.2059853*.

68. Bosher, L. English football finances in 'precarious position' - report. *The Athletic* (2023). *https://doi.org/10.1080/14660970.2022.2059853*.

69. Brannagan, P. M. *et al.* The 2021 European Super League attempt: motivation, outcome, and the future of football. *Int. J. Sport Policy Polit.* **14**, 169–176 (2022). *https://doi.org/10.1080/19406940.2021.2013926*.

70. Forman, M. No Sleep 'Til Brooklyn. *Am. Q.* **54**, 101–127 (2002). *https://www.jstor.org/stable/30042217*.

71. Quick, R. K. The cultural commodification of identity: Hip-hop authenticity. (University of Missouri, Columbia, MO, 2011).

72. Osman, S. Gentrification Matters. *J. Urban Hist.* **43**, 172–179 (2017). *https://doi.org/10.1177/0096144216680247*.

73. Wicks, A. S. Hip-Hop and the Dilution of Resistance in the Mainstream. (Vanderbilt University, Nashville, TN, 2018).

74. Ing, E. Hip-Hop street fashion, identity, and cross-Cultural appropriation in the Asian diaspora. *Proc. 56th Annu. Meet. ISSS - 2012 San Jose CA USA* (2013). *https://journals.isss.org/index.php/proceedings56th/article/view/1960*.

75. Brothwell, D. R. & Pollard, A. M. Archaeological Science: A Current Perspective. in *Handbook of Archaeological Sciences* (eds. Pollard, A. M. & Brothwell, D. R.) 507–518 (John Wiley & Sons, 2001).

76. Pollard, A. M. & Heron, C. *Archaeological Chemistry*. (Royal Society of Chemistry, Cambridge, 2008).

77. Hall, E. T. X-Ray Fluorescent Analysis Applied to Archaeology. *Archaeometry* **3**, 29–35 (1960). *https://doi.org/10.1111/j.1475-4754.1960.tb00514.x*.

78. Potts, P. J. & Sargent, M. In situ measurements using hand-held XRF spectrometers: a tutorial review. *J. Anal. At. Spectrom.* **37**, 1928–1947 (2022). *https://doi.org/10.1039/D2JA00171C*.

79. Heginbotham, A. *et al.* An evaluation of inter-laboratory reproducibility for quantitative XRF of historic copper alloys. in *Proceedings of the interim meeting of the ICOM-CC Metal Working Group, October 11–15, 2010* (eds. Mardikian, P., Chemello, C., Watters, C. & Hull, P.) 178–188 (Clemson University Press, Charleston, South Carolina, USA, 2011).

80. Smith, D. Handheld X-ray fluorescence analysis of Renaissance bronzes: practical approaches to quantification and acquisition. in *Handheld XRF for Art and Archaeology* (eds. Shugar, A. N. & Mass, J. L.) vol. 3 37–74 (Leuven University Press, 2013).

81. Dussubieux, L. & Walder, H. Identifying American native and European smelted coppers with pXRF: a case study of artifacts from the Upper Great Lakes region. *J. Archaeol. Sci.* **59**, 169–178 (2015). *https://doi.org/10.1016/j.jas.2015.04.011*.

82. Tykot, R. H. Using Nondestructive Portable X-ray Fluorescence Spectrometers on Stone, Ceramics, Metals, and Other Materials in Museums: Advantages and Limitations. *Appl. Spectrosc.* **70**, 42–56 (2016). *https://doi.org/10.1177/0003702815616745*.

83. Vianello, A. & Tykot, R. H. Investigating Technological Changes in Copper-Based Metals Using Portable XRF Analysis. A Case Study in Sicily. *Open Archaeol.* **3**, 392–408 (2017). *https://doi.org/10.1515/opar-2017-0025*.

84. Garrido, F. & Li, T. A handheld XRF study of Late Horizon metal artifacts: implications for technological choices and political intervention in Copiapó, northern Chile. *Archaeol. Anthropol. Sci.* **9**, 935–942 (2017). *https://doi.org/10.1007/s12520-016-0315-2*.

85. Nørgaard, H. W. Portable XRF on Prehistoric Bronze Artefacts: Limitations and Use for the Detection of Bronze Age Metal Workshops. *Open Archaeol.* **3**, 101–122 (2017). *https://doi.org/10.1515/opar-2017-0006*.

86. Robotti, S. *et al.* Reliability of portable X-ray Fluorescence for the chemical characterisation of ancient corroded copper-tin alloys. *Spectrochim. Acta Part B At. Spectrosc.* **146**, 41–49 (2018). *https://doi.org/10.1016/j.sab.2018.04.017*.

87. Emmitt, J., McAlister, A. & Armstrong, J. Pitfalls and Possibilities of Patinated Bronze: The Analysis of Pre-Roman Italian Armour Using pXRF. *Minerals* **11**, 697 (2021). *https://doi.org/10.3390/min11070697*.
88. Martinón-Torres, M. *et al.* Forty Thousand Arms for a Single Emperor: From Chemical Data to the Labor Organization Behind the Bronze Arrows of the Terracotta Army. *J. Archaeol. Method Theory* **21**, 534–562 (2014). *https://doi.org/10.1007/s10816-012-9158-z*.
89. Charalambous, A., Kassianidou, V. & Papasavvas, G. A compositional study of Cypriot bronzes dating to the Early Iron Age using portable X-ray fluorescence spectrometry (pXRF). *J. Archaeol. Sci.* **46**, 205–216 (2014). *https://doi.org/10.1016/j.jas.2014.03.006*.
90. Orfanou, V. & Rehren, Th. A (not so) dangerous method: pXRF vs. EPMA-WDS analyses of copper-based artefacts. *Archaeol. Anthropol. Sci.* **7**, 387–397 (2015). *https://doi.org/10.1007/s12520-014-0198-z*.
91. Lutz, J. & Pernicka, E. Energy Dispersive X-Ray Fluorescence Analysis of Ancient Copper Alloys: Empirical Values for Precision and Accuracy. *Archaeometry* **38**, 313–323 (1996). *https://doi.org/10.1111/j.1475-4754.1996.tb00779.x*
92. Fernandes, R., van Os, B. J. & Huisman, H. D. The use of Hand-Held XRF for investigating the composition and corrosion of Roman copper-alloyed artefacts. *Herit. Sci.* **1**, 30 (2013). *https://doi.org/10.1186/2050-7445-1-30*.
93. Porcinai, S., Cagnini, A., Galeotti, M. & Ferretti, M. Quantitative analysis of copper alloys by means of portable X-ray fluorescence: A comparison between analysis of shavings and surfaces. *Spectrochim. Acta Part B At. Spectrosc.* **210**, 106808 (2023). *https://doi.org/10.1016/j.sab.2023.106808*.
94. Roxburgh, M. A., Heeren, S., Huisman, D. J. & Van Os, B. J. H. Non-Destructive Survey of Early Roman Copper-Alloy Brooches using Portable X-ray Fluorescence Spectrometry. *Archaeometry* **61**, 55–69 (2019). *https://doi.org/10.1111/arcm.12414*.
95. Pearce, M. The Curse of the pXRF: the Negative Consequences of the Popularity of Handheld XRF Analysis of Copper-Based Metal Artefacts. *METALLA* **24**, 81–85 (2018). *https://doi.org/10.46586/metalla.v24.2018.i2.81-85*.
96. Heginbotham, A. *et al.* The Copper CHARM Set: A New Set of Certified Reference Materials for the Standardization of Quantitative X-Ray Fluorescence Analysis of Heritage Copper Alloys*. *Archaeometry* **57**, 856–868 (2015). *https://doi.org/10.1111/arcm.12117*.
97. Bhandare, S. A Brass Manilla from West Africa. *Ashmolean Museum Oxford* (2023). *https://www.ashmolean.org/article/brass-manilla-west-africa*.
98. Craddock, P. T. Medieval Copper Alloy Production and West African Bronze Analyses - Part I. *Archaeometry* **27**, 17–41 (1985). *https://doi.org/10.1111/j.1475-4754.1985.tb00344.x*.
99. Caley, E. R. & Shank, L. W. Composition of Two Manillas. *Numis. Chron.* **6**, 331–335 (1966). *https://www.jstor.org/stable/42665091*.
100. Craddock, P. T. & Picton, J. Medieval Copper Alloy Production and West African Bronze Analyses - Part II. *Archaeometry* **28**, 3–32 (1986). *https://doi.org/10.1111/j.1475-4754.1986.tb00371.x*.
101. Stockport Advertiser. Wreck of the Douro of Liverpool — All Hands Lost. *Stockport Advertiser* 1 (1843).
102. The Morning Chronicle. Scilly — Melancholy Shipwreck. *The Morning Chronicle* 8 (1843).
103. Kingsley, S. & Jacobovici, S. *Enslaved: The Sunken History of the Transatlantic Slave Trade*. (Simon and Schuster, 2022).
104. Jacobovici, S. (Director). Episode 2 — Rationalization. *Enslaved* (2020).

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PRESS SUMMARY

Metal, horseshoe-shaped bracelets known as manillas emerged during the early modern period (ca. fifteenth century AD) as a form of currency between western Europe and West Africa, and these items continued to circulate on both continents until the early twentieth century. Today, narratives about the bracelets abound. For some, they are most significant as the unofficial blood money of the transatlantic slave trade. For others, they are even more significant as the copper source used to make famous works of West African art, such as the Benin Bronzes. Meanwhile, still others uphold the manilla as a symbolically important form of West African jewelry in and of itself. In this article, we offer a history of the manilla, from its rapid proliferation to its eventual obsolescence. We propose that the term "metastasizing symbol" can be utilized to describe objects such as the manilla, whose propagation is underwritten by unsustainable systems of cultural difference and, thereby, contains within itself the seeds for the object's transition to disuse. Using X-ray fluorescence (XRF) data from nine manillas at the Yale University Art Gallery, we also demonstrate how chemical analysis can be used to augment the socio-cultural geography of the manilla.

Reporting on Antibiotic Resistance in Two US Newspapers Before and During Covid-19

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ABSTRACT
Antibiotic resistance (AR) is a growing health crisis that has remained underrepresented in coverage across major news publications in the U.S. despite increasing rates of related disease outbreaks and mortality worldwide. This study used content analysis to examine the coverage of AR in two major U.S. news publications before the COVID-19 pandemic (2018-2019) and during it (2020-2021). Coverage of AR in The New York Times (NYT) and The Washington Post (WP) was analyzed according to the use of frames, the quantity of articles published, and a number of other variables including stakeholders, diseases, and terms referring to AR. These factors were used to assess how coverage of AR differed before and during the COVID-19 pandemic, and how it differed between the two newspapers. Pre-COVID-19 coverage focused on AR as an isolated pandemic, while coverage during the early years of the COVID-19 pandemic often used AR as a supplementary component of the coverage to the main topic of COVID-19. This study found that both before and during the outbreak of COVID-19, the majority of the observed articles did not fully explain the scope, severity, or solution for the AR crisis. Instead, they provided readers with baseline information, framing AR as a contemporary issue and generally encouraging action but included very few tangible suggestions for every day, individual action for readers.

KEYWORDS
Superbugs; Frames; Antibiotic Resistance; Coronavirus; COVID-19; Media Coverage; Health Crises; Medicine

INTRODUCTION

Antibiotic resistance (AR) occurs when bacteria develop the ability to fight off the drugs designed to kill them, rendering the drugs ineffective.[1] Bacteria can gain this resistance and then spread it to other bacteria by transferring plasmids, or genetic information, between cells. This results in the exponential growth of these super-strains of borderline-invincible bacteria, also known as Superbugs. Note that certain fungi can also become resistant to drugs similar to bacteria and, in many parts of the world, this problem is referred to as antimicrobial resistance (AMR) rather than antibacterial resistance (AR) as it is commonly used in the United States. Superbugs continue to threaten the efficiency and reliability of modern medicine, adding risk to common surgeries and hospital procedures.[2] For nearly a century, antibiotics have helped to eradicate and alleviate common illnesses by blocking vital bacterial processes and helping the human immune system fight off infections. However, doctors, pharmaceutical companies, and most importantly patients are now facing a looming global health issue: resistance to these vital drugs.

Antibiotic resistance has escalated to a slowly growing health crisis, impacting roughly three million people and killing 35,000 annually in the United States, according to a 2019 Centers for Disease Control and Prevention (CDC) report.[3] Human behavior has acted as a catalyst for global outbreaks of various antibiotic resistant bacteria. One of the most prevalent acts is through antibiotic over prescription or inappropriate prescription.[4] A CDC study, using machine-learning modeling data from around 42 million U.S. patient visits for antibiotic-inappropriate acute respiratory infections, discovered that around 11% of those visits (over 4 million people) were inappropriately prescribed antibiotics. This occurred despite insufficient diagnosis codes for acute respiratory infections requiring antibiotics.[5] Overuse in the agricultural industries, especially in livestock,[6] has also exacerbated the problem, leading to the development and rapid reproduction rate of Superbugs through excess exposure to these antibiotics. Bacterial evolution is currently moving faster than pharmaceutical companies can develop new antibiotics to combat it. Problems in the drug pipeline, with not enough new antibiotics being researched by large drug companies that see no profit in it, combined with over-prescription and overuse, pose a possible grim future for the health of many populations.

While Superbugs have been spreading slowly for the last few decades, COVID-19, a strain of Coronavirus, spread quickly across global populations in only a few years. According to a 2024 dashboard update by the World Health Organization (WHO), COVID-19 has claimed more than seven million lives since 2020.[7] COVID-19 was declared a Public Health Emergency of International Concern (PHEIC) in January 2020, and the public watched case numbers oscillate and kept track of updates using social media and news platforms.

This study assessed how the AR coverage changed with the COVID-19 pandemic by comparing the coverage of AR in two major U.S. newspapers before the COVID-19 outbreak and after its onset in early 2020. Media coverage during the COVID outbreak is particularly interesting because it allows for the comparison between a slow-moving pandemic in antibiotic resistance and a fast-moving pandemic in COVID-19. This comparison also allows for an observation of how media coverage of creeping health crises can be overshadowed by other, more heavily covered topics, especially that of another pandemic. To evaluate these factors, we examined U.S. media's coverage on the development of AR in the widely distributed New York Times (NYT) and Washington Post (WP) in both print and online versions. We collected and coded articles in these publications over four years, looking at the two years preceding the onset of the COVID-19 pandemic, and during the pandemic's first two years to analyze the overall coverage of AR and how it changed with the addition of an immediate public health emergency.

LITERATURE REVIEW

Public Awareness of Antibiotic Resistance

Despite continuous rises in reported outbreaks and overall death tolls, major countries including Canada, Brazil, France, Germany, China, the United States, and more have yet to make antibiotic resistance a priority, as observed by the Global Coalition on Aging and the Infectious Diseases Society of America (IDSA). In a 2018 survey performed by the European Center for Disease Prevention and Control (ECDC) of over 18,000 healthcare workers, fewer than 60% were able to answer questions about antibiotics correctly, and only 58% agreed that they played an important part in preventing antibiotic resistance. The survey also noted that about 50% of respondents were uncertain about their country's plan to help prevent antibiotic-resistant infection outbreaks.[8]

A 2021 survey shows that only 46% of the public in Brazil, 51% in the United States, 63% in China, and 68% in India recognize AMR as a term.[9] This lack of public awareness is alarming in that it suggests that highly populated areas in major countries remain highly unprepared or unequipped to take measures against the spread of antibiotic resistant infectious diseases.

There have been some recent efforts to combat this lack of awareness, accompanied by specific calls for action to major countries detailing steps that can be taken against AR. A 2019 report by The Wellcome Trust emphasized the severity of antibiotic resistance by stating the death tolls and the impact that it has had on lower and middle income countries. It also proposed ways that different nations can mitigate the effects of bacterial development and drug failure including changing the ways in which antibiotics are dispensed, funding new drug development, educating communities about the problem in strategic ways, strengthening hospital and doctoral stewardship, and pioneering ways to detect the development of Superbugs in livestock.[10] Another call for action has been to pass the PASTEUR Act, a bill currently being presented to the U.S. congress that would allow the federal government to create more financial incentives for advancements in drug development and new antimicrobial treatments.

Media Influence on Infectious Disease Outbreaks

Hope for intervention is not all lost; coverage of infectious diseases across mass media platforms can help eliminate this lack of awareness through its effect on public opinion and forcing action against infectious diseases. A study at McMaster University found people tend to view diseases that are highly covered in the media as more severe than those that are less covered. Increasing rates of reporting of outbreaks also play an important role in perception of risk in a population.[11] Another report used theoretical projections based on psychology to find that, in general, during large outbreaks of infectious diseases with high mortality rates, individuals closely follow the news. As a result, they make efforts to minimize their exposure by isolating, which has a modest impact on overall morbidity. Media influence was strongest when media coverage was earlier in the outbreak; however, an increase in media exposure was found to minimize the severity of the infectious disease even when introduced later into the outbreak.[12]

The Impact of Journalistic Framing

Drawing public attention to media coverage of issues such as antibiotic resistance can be aided by a journalistic tool called framing. Differing representations or "frames" play a large role in situational analysis and perception of a given issue by an audience. Framing is a tool that is a key aspect of journalism as a whole, and it is particularly important when referring to health crises or trends within the mass media. "Specifically, news frames may be conceptualized as principles of selection, emphasis, and presentation composed of little tacit theories about what exists, what happens, and what matters…." The subject of often intense

negotiation between journalists and their editors, as well as their sources, frames help to render "an infinity of noticeable details" into meaningful categories.[13] Framing was investigated in a study related to opioid research in media, where it was found that most news stories were framed as "facts," however, in reality, it was rare that the presented information was sufficiently evaluated for its validity. The study mentions that many of the articles published in the mass media on opioid research often took findings from scientific journals out of context and inaccurately conveyed a lack of research in a given topic, or framed related research as controversial.[14]

This misinformation amongst audiences and its effect on reader understanding in regards to AR was also investigated in a recent study. Here, the impact of framing on public perception of AR overuse in livestock was examined using a survey. It was found that multiple frames, including the "blame frame," which described AR as a result of antibiotic overuse as an effort to combat animal welfare issues, had notable impacts on consumer trust. It was also found that readers were more likely to trust information when it was framed in a way that took the blame off of themselves, and rather placed the blame on the agricultural industry.[15] These findings exemplify how a media portrayal may alter the perception of major health events of crises and ultimately affect resulting outcomes in terms of audience impression.

Present Study

This study analyzed coverage on antibiotic resistance over two time periods in the NYT and the WP in terms of how and to what extent it was being covered. We sought to analyze how antibiotic resistance was presented and described in each given WP and NYT article, which stakeholders were represented within the articles, and the suggested actions that could be taken away from each article to help fight against the health threat. Building on past reports on AR published by PEW Charitable Trust,[2] the World Health Organization,[7] the Centers for Disease Control and Prevention[3], as well as the Wellcome Trust,[10] we aimed to answer the following research questions:

1. *What journalistic frames were most predominant across publications? How does this affect the overall perception of antibiotic resistance?*
2. *What happened to the coverage of antibiotic resistance once COVID-19 became a major coverage topic?*
3. *Were multiple terms used to discuss AR? Which were the most prevalent?*
4. *Was the coverage driven by different diseases or outbreaks?*
5. *What groups or organizations (stakeholders) were most often cited in the articles?*
6. *Were any actions suggested to improve or combat the situation?*
7. *Were there differences in coverage between the two national newspapers in the coverage of AR?*

METHODS AND PROCEDURES

To better understand antibiotic resistance both as a concept and health threat, we initially researched the threats that AR poses to public health, why it is important that people be informed about these threats, and how and to what capacities they are being conveyed and reported on in major media outlets. We reviewed reports on antibiotic resistance and various programs sponsored by the CDC, FDA, WHO, and the Wellcome and Pew Trusts.

We patterned part of our study on "Reframing Resistance," a study done by the Wellcome Trust Foundation in 2019,[9] which examined media coverage of AR in five countries including the United States. The Wellcome Trust is a global charitable foundation based out of the UK that is dedicated to health-based research in the topics of mental health, climate and health, and infectious disease. The Wellcome Trust conducted a robust study of frames across antibiotic resistance coverage by various media outlets. *Reframing Resistance* was a qualitative analysis that categorized AR coverage into five major frames. The results of the study suggested changes to the ways in which antibiotics are dispensed, funding new drug development, educating communities about the problem in strategic ways, strengthening hospital and doctoral stewardship, and pioneering ways to detect the development of Superbugs in livestock. We were particularly interested in seeing how our two newspaper findings compared to those of the Wellcome Trust's earlier U.S. findings.

The Wellcome Trust coded AR media coverage under the following frames: Undermining Modern Medicine, Explain the Fundamentals Succinctly, Emphasis that this is a Universal Issue, Focus on the Here and Now, and Encourage Action. We utilized these frames in our coding research, and added additional frames (Apocalyptic, Political, Personal, Optimistic, and Economic) based on our review of the literature to further categorize the articles that we observed. The first frame we used in this study was "Undermining Modern Medicine," in which articles described bacterial-resistant infections as lessening the effectiveness of modern treatment options, including those not directly related to the bacterial-resistant infections themselves. The second frame used was "Universal Issue," in which articles stated antibiotic resistance affects everyone, and is a threat to all. The third frame used was "Here and Now," which described antibiotic resistance as a problem that is occurring now, as opposed to an issue in the far-future. Words and phrases like "urgent," "today," and "right now" were some examples of key indicators for this frame.

The fourth frame was "Encourage Action," which focuses on preventing unnecessary death and suffering, and more specifically a push to take action. Words and phrases like "take action" and "act upon" were key indicators of this frame. "The fifth frame we considered was "Apocalyptic," in which articles described antibiotic resistance as a threat to "return to dark ages." The sixth frame was "Political," in which articles focused specifically on government action or inaction in regards to preventing AR. The seventh frame was "Personal," which focused on consumerism, individual examples of antibiotic overuse, and a lack of public awareness on AR. The eighth frame was "Optimistic," in which articles encouraged more research, called for the development of new antibiotics, and approached AR with a hopeful mindset. The ninth frame was "Economic," which focused on economic damage as a result of AR, increases in the cost of healthcare, and pharmaceuticals. Any articles with frames that did not fall under these categories were placed in an "Other" category.

We developed an analytical codebook to categorize articles that were collected from ProQuest after our initial research. These categories allowed us to obtain a detailed outline and understanding of the desired parameters of coding for each variable, which led us to more precise results and analysis. Relevant articles were coded for 32 variables, including present stakeholders, different diseases mentioned, and the words used to refer to antibiotic resistance. We cataloged the stakeholders, that is, the types of persons and organizations involved in mitigating the fallout of future Superbugs, the scope of the future resistance-based pandemics, and the ways in which this issue was framed by these major newspapers. We used the codebook that we developed to compare the coverage and framing of AR before and after the onset of COVID-19.

We used the ProQuest database to gather relevant articles from the NYT and WP. We chose to look at these publications specifically because they are both major sources of many people's daily health information. Using ProQuest, we conducted advanced, targeted searches to find all of the articles mentioning a series of key search terms pertaining to antibiotic resistance and used the codebook to break down coverage within relevant articles. The first search, focusing on articles published between Jan. 1, 2018 and Dec. 31 2019, avoided COVID-19 as a confounding factor. Articles for the pre-COVID-19 search (2018-2019) were obtained using the following search terms:-((antibiot* OR "antimicro* OR antifun* OR drug) NEAR/5 resistan* OR "superbug*) for dates from Jan. 1, 2018 to Dec. 31, 2019. We then repeated the process for a second search, focusing on articles published in the two newspapers during 2020 and 2021 after the initial coronavirus outbreak. We added additional coding categories to collect COVID-19-related information. These categories were related to whether COVID-19 was mentioned in the article, what terms were used to reference COVID-19 and how it was framed, if a connection was made between COVID-19 and AR, and if antibiotics or ventilators were involved in the treatment of COVID-19. No book reviews or obituaries were included in the final article count and irrelevant or duplicate articles were eliminated from the final coding. All articles were coded by two people to ensure accuracy. Coding disagreements were negotiated by the coders, with occasional faculty assistance.

We then input all of the coded data into Excel spreadsheets and checked them with one another to ensure intercoder reliability. Using Excel, we compared and sorted through our data by putting them into graphs to visualize and analyze the data that we collected. SPSS 29 was used to analyze the data, focusing on differences between the two newspapers and between pre-COVID and during COVID coverage. Chi-square contingency tests showed no statistical significance in data comparison between the NYT and WP. However, there were some significant differences in the number of articles and the major frames used based on the timeframe. Standardized adjusted residuals were used for post-hoc analysis of the significant chi-square tests. These findings will be detailed below in the results section.

RESULTS

Compiled Results from 2018-2021

The total number of articles found in the NYT and the WP regarding antibiotic resistance was relatively small: 176 articles in the NYT and 112 in the WP from 2018-2021. Comparing the total article count in both publications by year, 39 articles were published in 2018, 145 were published in 2019, 50 in 2020, and 52 in 2021, with notable spikes in both newspapers in April 2019, August 2019, and December 2019 (see Table 1). A goodness of fit test comparing the number of articles in each of the four years showed significant differences between them ($\chi 2$ (3, 288) = 102.86. p<.001). A goodness of fit comparing pre- and post-COVID-19 articles likewise revealed statistically significant differences in the number of articles between these two time periods ($\chi 2$ (1, 288) = 23.36. p<.001)

There were notable spikes in antibiotic resistance coverage during select months in the study. In April 2019, a total of 14 articles appeared in both publications about antibiotic resistance. It can be inferred that this increase in articles came as a result of an outbreak of the infection *Candida auris*. In August 2019, 14 articles were published by the NYT, and six were published by the WP. This increase can be attributed to the development of a successful treatment for an antibiotic strain to tuberculosis, which was covered in 32 articles by the NYT. In December 2019, the NYT published 18 articles about antibiotic resistance, and the WP published 11. The NYT coverage looked at a variety of topics including the bankruptcy of pharmaceutical companies trying to improve the drug pipeline, the use of antibiotics in the swine industry, and the bacteria in the Ganges River. This increase in 2019

coverage comes as a result of a NYT series of articles about antibiotic resistance titled, "Deadly Germs, Lost Cures." The series was primarily written by reporters Matt Richtel and Andrew Jacobs, and it covered a wide range of topics surrounding the issue of antibiotic resistance. The series started in 2019, had occasional articles throughout the year and three articles from this series were published in December 2019. Each article was accompanied by several summarizing briefs and sidebar stories about the issue. Since the articles within the series were so dispersed over the year, with different authors, it would have been difficult for readers to identify it as a significant coverage effort on the AR topic.

The degree of discussion about AR differed across articles. In all coded articles, 57.64% (n = 166) "only briefly discuss/mention AR and were on another topic," 40.28% (n= 116) "mostly discuss AR," and 2.08% (n = 6) "were listings of various articles; briefs." In the 211 articles that only mentioned AR (did not mention COVID-19), 50.24% (n = 106) "only briefly discuss/mention AR and were on another topic," 47.87% (n = 101) "mostly discuss AR," and 1.90% (n = 4) "were listings of various articles; briefs." In the 77 articles that mentioned both AR and COVID-19, 77.92% (n = 60) "only briefly discuss/mention AR and were on another topic," 19.48% (n = 15) "mostly discuss AR," and 2.60% (n = 2) "were listings of various articles; briefs."

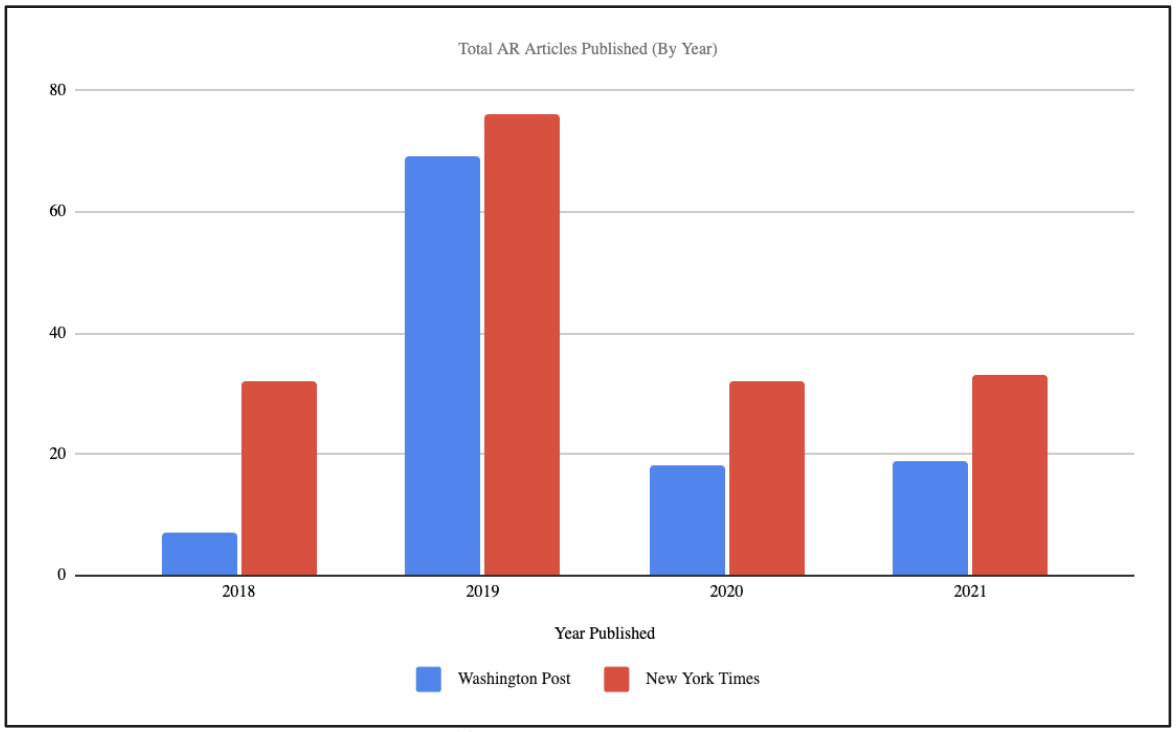

Figure 1. Total antibiotic resistance articles by year.

Major Frames

Overview of Results: The five major frames included in the 2019 Wellcome Trust search as well as four additional frames were included in this study. Of these, two were the most prevalent, dominating all of the others in both newspapers in our study. The most common major journalistic frame used was to "Encourage Action," which focuses on preventing unnecessary deaths or suffering. The second most common major frame used was a "Focus on Here and Now," which emphasizes that this issue is not a far-future problem, but rather a problem occurring now; it is immediate. The least common journalistic frame found was "Economic" which focused on a return to "dark ages," doom and gloom, and an impending sense of doom centered around pandemics and epidemics.[9]

Year by Year Comparison: There were significant differences between the major frames used in 2018-2019 compared to 2020-2021 ($\chi 2$ (8, 288) = 32.74 p<.001). In 2018, the most common frame in both the NYT and WP was "Encourage Action" and in the years 2019-2021, the most common frame in both the NYT and WP was "Focus on Here and Now." Post-hoc tests with the Bonferroni correction suggested three significant pairwise comparisons. Concretely, the "Encourage Action" frame appeared more frequently in the COVID-19 period compared to the pre-COVID-19 period than would be expected by chance; the "Apocalyptic" frame appeared more frequently in the pre-COVID-19 period than the COVID-19 period than would be expected

by chance; and none was present more frequently in the pre-COVID-19 period than the COVID-19 period than would be expected by chance. See Table 1 for a summary of this data.

FRAMES	2018-2019	2020-2021	Total	Significance
Undermining Modern Medicine (*n*, %)	22, 11.9%	10, 9.7%	32	Z = -.6, p = .59
Here and Now (*n*, %)	44, 23.8%	16, 15.5%	60	Z= -1.7, p = .09
Encourage Action (*n*, %)	28, 15.1%	33, 32.0%	61	Z = 3.4, p < .001*
Apocalyptic (*n*, %)	20, 10.8%	1, 1.0%	21	Z = -3.1, p = .002*
Political (*n*, %)	10, 5.4%	4, 3.9%	14	Z = -.6, p = .59
Personal (*n*, %)	17, 9.2%	15, 14.6%	32	Z = 1.4, p = .16
Optimistic (*n*, %)	19, 10.3%	18, 17.5%	37	Z = 1.8, p = .07
Other (*n*, %)*	7, 3.8%	5, 4.9%	12	Z = .4, p = .67
None (*n*, %)*	18, 9.7%	1, 1.0%	19	Z = -2.9, p = .003*

Table 1*:* Comparison of Major Frame Prevalence between 2018-2019 and 2020-2021. *Note.* For chi-square analyses and cell comparisons using Z-scores, we used Bonferroni Correction, such that significant p-value was set to p < .005. * = statistically significant group differences at p < .01 level.

During 2018, prior to the outbreak of the COVID-19 pandemic, only one article had an Encourage Action frame, meaning that antibiotic resistance was not viewed as a health crisis that required immediate personal action in 2018. However, in the following years, during the onset of the COVID-19 pandemic, the number of articles across both publications using this frame increased and remained relatively steady. In 2019, before COVID-19 became a major topic in the news, 27 articles across both publications used the Encourage Action frame. In 2020, after COVID-19 was declared a pandemic, 12 articles used this frame; and in 2021, 21 articles had Encourage Action as the dominant major frame.

Conversely, the second most prominent frame, Focus on the Here and Now, was most prominent in the earlier years of the study and waned in the following years, as the COVID-19 pandemic began to dominate the media. In 2018, there were 22 articles across both publications that primarily looked at antibiotics under the Focus on the Here and Now lens. In 2019, there were 22 total articles; in 2020, there were six; in 2021, there were 10 articles across both newspapers that used the Focus on the Here and Now frame. Overall, the NYT published more articles under both frames, and the two most prominent major frames had inverse trends in the observed media outlets over the course of the measured years.

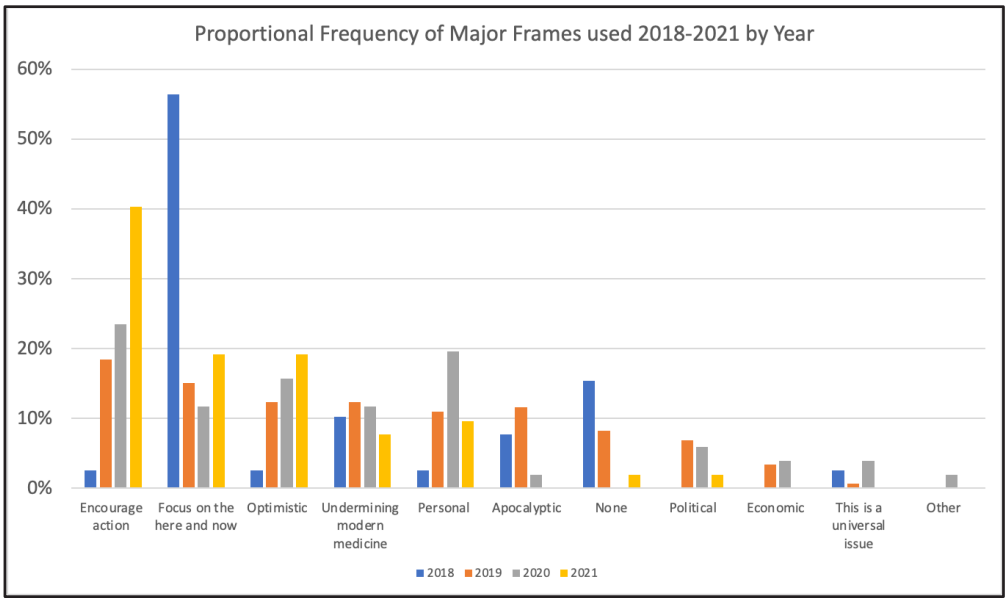

Figure 2. Proportional frequency of major frames used to characterize antibiotic resistance in articles published, broken down by year.

Description of Antibiotics

Overview of Results: Having an understandable and relatable definition of antibiotic resistance for readers was important for luring them into reading the articles. The newspaper articles described antibiotic resistance for their readers in several ways. The most common description was "antibiotics have become ineffective or stopped working," which states that antibiotic resistance is when antibiotics have become obsolete for treatment purposes. The "Ineffective Antibiotics" description was found in 119 of 288 total articles, or 41.32% of total articles. The second most common description was a more scientifically accurate description of the situation that concerned bacteria and their development of resistance to antibiotic drugs, their behavior and evolution. This was discussed in 92 articles over the four years of the study. As shown in Figure 3, there was a lower frequency of articles describing antibiotic resistance as issues related to overuse of antibiotic drugs by doctors, hospitals, consumers or in agriculture or farming.

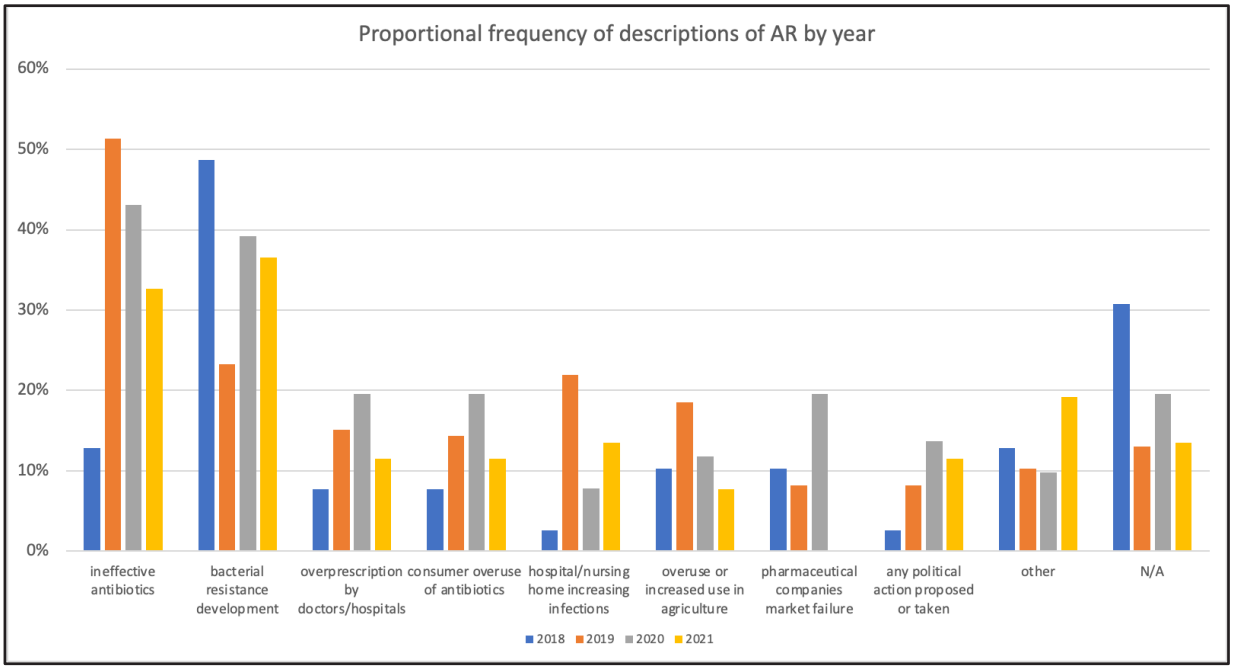

Figure 3. Proportional frequency of descriptions of antibiotic resistance in articles published, broken down by year.

Diseases Mentioned

Overview of Results: The most prominent disease mentioned in both publications from 2018 to 2021 was HIV, with 12.11% of all articles (n = 50) detailing the relationship between antibiotic resistance and HIV. Another commonly mentioned disease was tuberculosis or "TB." This was mentioned in 11.86% of total articles (n = 49). *Candida auris* also appeared in a notable number of articles; mentioned in 7.51% of all articles (n = 31). Seventy-nine of the articles across both publications from 2018-2021 discussed other diseases or very specific infections relevant to antibiotic resistance.

Year by Year Comparison: HIV representation saw consistent numbers across all years in terms of articles it was mentioned in relative to articles published. As for tuberculosis, there was a spike in its frequency, appearing in 24 articles in 2019 across both publications and only 25 total articles across both publications over the years 2018, 2020, and 2021. There was also a spike in both publications for *Candida auris*, as it was mentioned in 29 articles in 2019 across the WP and the NYT and just 2 total articles in both publications in the years 2018, 2020, and 2021.

Terms Referring to AR

Overview of Results: The most prominent term used to describe antibiotic resistance in both publications from 2018 to 2021 was, "drug-resistant infections," with 129 of the total 473 articles (28%) using this term to refer to the health crisis. The second most used term was "antibiotic resistance or AR," with 126 articles (27%) of the total article count from 2018-2021) across both media outlets using this term.

Stakeholders

Overview of Results: Many types of groups of people deal with AR and have a stake in how it is treated and researched and how antibiotics are used. The most prevalent group of stakeholders mentioned or appealed to within the articles dealt with medical professions: doctors, patients, and hospitals. As stakeholders, doctors appeared in 48.26% total articles (n = 139); patients appeared in 48.26% total articles (n = 139); and hospitals appeared in 50.35% (n = 145). This trend remained relatively static across the years 2018-2021, with doctors, patients, and hospitals staying as some of the most present stakeholders across all years. Another prevalent stakeholder within these publications was the CDC, which remained relatively constant in terms of frequency across all years. It appeared as a stakeholder in 32.29% of articles (n = 93). Universities were also a prevalent stakeholder across all years, appearing in 37.5% of articles (n = 108). There was a general lack of representation given to agricultural companies as a stakeholder for antibiotic resistance, despite the amount of antibiotics used by the agriculture industry. Agricultural companies appeared as a stakeholder in only 10.76% of total articles across all years between both publications (n = 31).

Suggested Actions

Overview of results: Outside of related topics regarding antibiotic resistance and important stakeholders, descriptions, and providing general information on the crisis, reporters also tried to present some possible solutions to the situation. The most commonly suggested action to combat antibiotic resistance across the articles was a call for a "Search for New Drugs." This was a suggested action in 32.64% total articles (n= 94). This was followed by the suggested action of "More Funding or Resources for Research," which was present in 27.78% of total articles over 2018-2021 in both publications (n = 80).

New York Times versus Washington Post Coverage

Looking at major journalistic frames in NYT and WP articles, the "Encourage Action" frame was the major journalistic frame for 37 of 176 NYT articles (21.02%) and 24 of 112 WP articles (21.43%). There was a small but interesting change in the major frames during the study years. The major journalistic frame within the articles in 2018 was a "Focus on Here and Now," accounting for 62.5% of the NYT articles (n=20) and 28.57 (n=2) of the WP articles. The major journalistic frame in 2019 articles across both publications was "Encourage Action," which applied to 18.18% NYT articles (n=14), and 18.84% of the WP articles (n=13).

The leading major frame in 2020 NYT articles was "Encourage Action," which accounted for 29.41% (n=10) of the articles, and the major journalistic frame in 2020 WP articles was a tie between "Drug-Resistant Infections are Undermining Modern Medicine," "Focus on the Here and Now," "Political" (Government Action or Inaction), and "Personal," with each being applicable to 17.63% (n= 3). This makes the most prevalent major journalistic frame across both WP and NYT articles "Encourage Action," which applies to 23.53% (n=12) of the articles (23.53%).

In the 2021 articles, the most common major journalistic frame in the NYT was Encourage Action, accounting for 36.36% (n=12) of the published articles. The most common major journalistic frame in the WP in 2021 articles was also Encourage Action, which was applicable to 47.37% (n=9). This makes Encourage Action the most prevalent major journalistic frame across all 2021 articles; applicable to 40.38% (n=21) of the total articles from both publications released in 2021.

When describing antibiotics within the publications, "Ineffective Antibiotics" was the most common description in both the NYT and WP in articles published from 2018-2021. This description was used in 34.09% (n=60) of the NYT articles, and 52.68% (n=59) of the WP articles.

The terms used to describe antibiotic resistance somewhat varied between the NYT and the WP. "Drug-resistant infections" was used more frequently in articles published by the NYT in 2018 and 2019, found in 33% in 2018 and 34% in 2019 of the articles published during these years. This description was used fewer times in 2020 and 2021, with only 14-21% of the articles using it to describe antibiotic resistance. The same term was not used at all in the WP in 2018. However, in 2019, 2020, and 2021, the number of articles published by the WP that used this term was relatively close to the number of articles published by the NYT that used this term to refer to antibiotic resistance.

Connecting the effects of antibiotic resistance with other diseases somewhat differed between newspapers. From 2018-2021, significantly more articles were published by the NYT that mentioned HIV, but the number of articles published each year across both publications that mentioned HIV was relatively consistent. This was the same for tuberculosis and *Candida auris*, which also showed relatively consistent numbers in articles mentioned when comparing the NYT to the WP.

As for stakeholders, both the NYT and WP followed the same general patterns, exhibiting minimal differences in their coverage. Doctors, patients, and hospitals remained the most prevalent stakeholders in both the NYT and WP articles across all years. Universities remained a top stakeholder in both the NYT and WP, appearing in 41.48% of the NYT articles (n = 73) and 31.25% of WP articles (n = 35). The CDC was a prevalent stakeholder across all years in both publications as well, including 28.41% of total NYT articles (n = 50) and 38.39% of 112 WP articles (n = 43). In both the NYT and WP, agricultural companies saw minimal representation, including mentions in just 10.80% of total NYT articles (n = 19) and 10.71% of total WP articles (n = 12).

Like stakeholders, the NYT and WP presented similar patterns of suggested actions. The most suggested action to combat antibiotic resistance in the NYT and the WP was a call for a "Search for New Drugs." This was a suggested action in 31.18% of NYT articles (n = 56) and 33.93% of WP articles (n = 38) . This was followed by the suggested action of "More Funding or Resources for Research," including 28.41% of total NYT articles (n = 50) and 26.79% of WP articles (n = 30).

DISCUSSION

Overview

The coverage of antibiotic resistance over time showed observable patterns in both journalistic framing and future direction. When looking at the media outlets and organizations involved in this study, there was a consistent pattern in which healthcare providers were posed heavily at being at fault for the spread of antibiotic resistance. The articles observed undermined antibiotic resistance as a problem requiring systemic change across multiple sectors, including governments, nonprofit organizations and the public, and instead focused primarily on just one branch of potential sources of error that has boosted antibiotic resistance in recent years. The blame overwhelmingly dealt with healthcare professionals rather than individual action, leaving the vast majority of readers unaware of their role in the issue or how it may affect them on a personal level. It seemed that the coverage was somewhat limited to healthcare-related issues, which may leave readers more likely to place fault on mistakes within the healthcare system rather than feeling motivated to make changes in their daily lives and actions to help reduce antibiotic resistance; essentially ignoring other prevalent sources of interest that contribute to AR. Although intervention dedicated to ensuring antibiotic prescription only when necessary, can be largely beneficial to physicians[16] and others working in pharmaceuticals,[17] there is still a notable discrepancy in the representation of other sectors that play a role in antibiotic resistance.

There was also a notable lack of attention given toward the agricultural sector of antibiotic resistance. Despite being one of the major contributors to antibiotic resistance, there was a minimal amount of coverage on the food industry as a whole, and minimal information on how factors like an overuse in antibiotics in animals may increase AR relative to human-based factors across both publications.

This overwhelming focus on systematic change rather than individual change is supported by the results seen when concerning suggested actions, with the most prevalent being a "Search for New Drugs" and "More Funding or Resources for Research." These are temporary solutions to the problem, as bacteria will continue to adapt to newly discovered/ distributed antibiotics. Temporary solutions are important; however, the articles did not focus as much on preventative and definitive measures for slowing antibiotic resistance.

The suggested actions also exhibit the same issue seen in the stakeholders section, in which there is a lack of attention given to other sectors that influence antibiotic resistance including more public information/understanding, more/better media coverage

of the situation, reduced use of broad spectrum antibiotics, etc. It is also important to note that a "Search For New Drugs" and "More Funding or Resources for Research" offer systematic change rather than providing information on individual actions that can be taken by readers within their everyday life.

Comparison to the Wellcome Trust

Our findings differ from the findings of the robust framing study conducted by The Wellcome Trust in timeframe, including newspapers, variables, and framing outlines. The Wellcome Trust found that in terms of sheer volume, the United States only published 366 articles from 10 different news outlets about antimicrobial resistance in the 12-month period between 2018 and 2019.[10] The Wellcome Trust found that the most compelling frame used to describe Antibiotic Resistance was the "Undermining Modern Medicine" frame, because it gives readers the sense that they are being set back in time, and the most effective frame was the "Explain the Fundamentals Succinctly" frame, which is not a frame that we included in our study, but they found that it gave readers a straightforward explanation for what the issue is.

The Trust found through quantitative studies that headlines that used more negative statements and statistics, about subjects such as death tolls, were less compelling to individuals, which aligns with the low number of articles that we found in our study that utilized the "Apocalyptic" frame. Even though they deemed it less effective than sharing straightforward facts, the Wellcome Trust acknowledged that many current communications around antibiotic resistance in the media focus on projections and warnings, thus falling into the "Focus on the Here and Now" frame, which was one of the most prominent major frames that we found in our study.[10]

The study done by the Wellcome Trust found that pneumonia, diarrhea, colitis, and gonorrhea were the most common diseases mentioned in articles in the United States that were influenced by drug-resistant infections, while our study found that HIV, TB, and *Candida auris* were the most commonly mentioned diseases in the WP and the NYT in the time period that we observed.[10] The Wellcome Trust found that a wide variety of terms were used to describe AR, and they were divided by tone.

The NYT and the WP had the fewest percentage overall of articles covering AR compared to other US publications, according to the Wellcome Trust, which may explain the lack of statistical evidence in our study for the findings of the Wellcome Trust. The Wellcome Trust studied a diverse set of mainstream print and online publications across the UK, US, and Germany totaling 1621 news items, including duplicate pieces. This is a notable difference in comparison to the 288 total articles in this study, not including duplicate pieces. The Wellcome Trust collected data from articles published from January 31, 2017 to January 31, 2018, contrasting from the timeline of January 2018 to December 2021, which encompasses different public health outbreaks (COVID 19 in particular) across a longer period of time.

CONCLUSIONS

The articles published between 2018 and 2021 in the NYT and the WP informed readers briefly and generally about what antibiotic resistance is, where these strains of bacteria are found, and how they are being treated in the current world.

Articles published in 2018 and 2019 contained significantly more informational content about the factors that contribute to the development of antibiotic resistant infections. The articles that focused on AR went into more depth about the science of Superbugs, detailing how cell plasmids transport these infections between organisms, giving readers background information about the topic and making information about the issue accessible. These articles established connections between the contributing factors, stakeholders, risks, and action plans involved in the study of AR, allowing readers to glean a holistic understanding of this issue as a looming public health crisis. Several of these articles used narrative, or feature storytelling, techniques to engage the senses and emotions of the readers to convince them of the severity of this health crisis. However, these informative articles made up only a small fraction of these collected articles.

The majority of the articles across both time periods only briefly mentioned antibiotic resistance, or used it as a supporting element, or mentioned risk, in the discussion of a different topic. As a result, these articles often did not serve the readers in that they did not fully explain the scope, severity, or solutions for the oncoming AR crisis. Across all 288 coded articles, over half were determined to "only briefly discuss/mention AR." This indicates that the articles were not likely to give sufficient or extended coverage of AR, but were rather supplementing it to support a separate topic, such as a new medical practice or other health crises (COVID-19, for example). This problem became even more apparent in articles after the start of the pandemic, with 60 of 77 total articles that mention both COVID-19 and AR falling under the category of "only briefly discuss/mention AR." There is a notable discrepancy in sample size between articles only mentioning AR and articles mentioning both COVID-19 and AR, however, this pattern can be investigated further to compare this potential shift in media coverage pre-pandemic and post-pandemic. To improve coverage, these articles could have included additional resources and information to better communicate the scope and severity of AR.

All articles tended to provide baseline information about antibiotic resistance and its expected rise within the near and extended future. There was minimal information given within the articles as to how to slow the spread, and instead they tended to focus on various alarming statistics and shortcomings in current approaches. Despite a journalistic frame calling for action, there were typically little-to-no specifics about how readers can become involved in the movement on an individual level. As mentioned previously, antibiotic resistance was often a secondary focal point across coded articles. Readers of the NYT and the WP would have benefited greatly from more articles with a primary focus on providing information about antibiotic resistance and a deeper analysis of how audiences can become involved in the fight against its spread on both a systemic and individual scale.

Newsworthiness describes whether a topic is relevant or interesting enough to cover in the media. It is directly related to the timeliness of a given issue being covered. The relationship between prevalence and popularity results in a pattern where more immediate, or trending, topics receive more coverage. This trend was observed in our assessment of the coverage of COVID-19, a fast-acting, global health crisis, and AR, a slowly advancing health threat. We found COVID-19 received notably more media attention than AR, despite increasing reports of global AR outbreaks and mortality projections far greater than the then-current COVID-19 death count. A report by WHO estimating by 2050, the AR annual mortality rates will reach up to 10 million.[18] According to our results, the media outlets we looked at began to shift away from framing AR as a crisis that required immediate action. Articles mentioning COVID-19 and AR, tended to refer to AR as a supporting example of a looming epidemic, comparing it to the COVID-19 outbreak, or as a result of early COVID-19 treatment. Seeing as how this coincided with rising COVID-19 cases, it can be inferred that COVID-19 drew public attention away from AR. While COVID-19 was an important topic to cover, a more balanced media focus on both crises could have yielded more informative, impactful coverage.

In a post-COVID-19 world, major publications such as the NYT and the WP will continue to give the most media attention to the most imminent health crises that are impacting the largest populations. The onset of the COVID-19 pandemic drew attention away from the issue of AR because it was fast acting and directly affecting the daily lives of populations globally. As a result, AR was mentioned more briefly and in less depth across major media outlets. As Superbugs spread and continue to render antibiotics unsuccessful, AR will become a more imminent issue facing society. If regulations to manage the careless use of antibiotics are not put in place and there is a continued lack of progress and attention to the development of new antibiotic drugs, AR will become a more serious issue. There is a continuous fight against time to inform the public and put preventative measures into action, with COVID-19 serving as just one example of the speed and sudden nature of pathogenic evolution and development. Implementing a dedicated mission to spread awareness of AR in the U.S. and globally could yield more effective media coverage and ultimately leave people more equipped to combat infectious diseases going forward.

This study had several limitations, the most prevalent of which dealt with the small number of articles found in the newspapers. The study was also directly affected by the COVID-19 pandemic and related COVID-19 protocols and health and safety restrictions. All group meetings were held virtually over Zoom, which created some difficulty in forming a consistent workplace environment. Future studies on mass media coverage of antibiotic resistance in the United States could explore how AR is covered in different types of media outlets including television and social media, particularly X and TikTok.

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REFERENCES

1. Martin MJ, Thottathil SE, Newman TB. (2015) Antibiotics Overuse in Animal Agriculture: A Call to Action for Health Care Providers. *American Journal of Public Health Volume 105 Issue 12, 2409-2410. doi: 10.2105/AJPH.2015.302870*
2. Cahill, K. (2022) Superbugs: A Global Health Threat, PEW Charitable Trust, *https://www.pewtrusts.org/en/trust/archive/winter-2022/superbugs-a-global-health-threat* (accessed June 2022)
3. *Antibiotic Resistance Threats in the United States 2019, https://stacks.cdc.gov/view/cdc/82532* (accessed June 2022)
4. Llor C, Bjerrum L. (2014) Antimicrobial resistance: risk associated with antibiotic overuse and initiatives to reduce the problem. *Therapeutic Advances in Drug Safety Volume 5, Issue 6, 220-254. doi: 10.1177/2042098614554919*
5. Antibiotic Use in the United States, 2022 Update: Progress and Opportunities (2022), Centers for Disease Control and Prevention, *https://www.cdc.gov/antibiotic-use/stewardship-report/current.html* (accessed June 2022)
6. Sustaining Global Action on Antimicrobial Resistance, *https://wellcome.org/sites/default/files/sustaining-global-action-on-antimicrobial-resistance.pdf* (accessed Jan. 2022)
7. WHO Coronavirus (COVID-19) Dashboard, *https://covid19.who.int/* (accessed June 2022)
8. Survey of healthcare workers' knowledge, attitudes and behaviours on antibiotics, antibiotic use and antibiotic resistance in the

EU/EEA *(2018), https://www.ecdc.europa.eu/sites/default/files/documents/survey-of-healthcare-workers-knowledge-attitudes-behaviours-on-antibiotics.pdf* (accessed June 2022)
9. *2021 AMR Preparedness Index, https://globalcoalitiononaging.com/wp-content/uploads/2021/06/GCOA-AMR-Preparedness-Index_FINAL.pdf* (accessed June 2022)
10. Reframing Resistance: How to communicate about antimicrobial resistance effectively, *https://cms.wellcome.org/sites/default/files/2020-11/reframing-resistance-report.pdf* (accessed June 2022)
11. Young ME, Norman GR, Humphreys KR. (2008) Medicine in the popular press: the influence of the media on perceptions of disease. *PLoS One Volume 3, Issue 10, e3552. doi: 10.1371/journal.pone.0003552*
12. Mummert A, Weiss H. (2013) Get the news out loudly and quickly: the influence of the media on limiting emerging infectious disease outbreaks. *PLoS One Volume 8, Issue 8, e71692. doi: 10.1371/journal.pone.0071692*
13. Anderson A, Allan S, Wilkins C. (2005) The Framing of Nanotechnologies in the British Newspaper Press. *Science Communication Volume 27, Issue 2, 200-220. doi: 10.1177/1075547005281472*
14. Matthias L, Fleerackers A, Alperin JP. (2020) Framing Science: How Opioid Research Is Presented in Online News Media. *Frontiers in Communication, Vol. 5, 64 doi: 10.3389/fcomm.2020.00064*
15. Steede GM, Meyers C, Li N, Irlbeck E, Gearhart S. (2020) The Influence of Framing Effects on Public Opinion of Antibiotic Use in Livestock. *Journal of Applied Communications, Volume 104, Issue 2. doi: 10.4148/1051-0834.2291*
16. Wasylyshyn AI, Kaye K, Chen J, Haddad H, Nagel J, Petrie J, Gandhi T, Petty L. (2022) Improving antibiotic use for sinusitis and upper respiratory tract infections: A virtual-visit antibiotic stewardship initiative. *Infection Control & Hospitality Epidemiology Volume 45 Issue 6, 1890-1893. doi: 10.1017/ice.2022.19*
17. Shinoda Y, Ohashi K, Matsuoka T, Yoshimura T. (2022) Analysis of pharmacological interventions among hospitalised patients with COVID-19: A focus on severe cases. *Biomed Reports Volume 18 Issue 2, No. 11 doi: 10.3892/br.2022.1593*
18. Antimicrobial resistance. *https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance.* (accessed Jan. 2024)

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PRESS SUMMARY

This study found antibiotic resistance to be a health crisis generally under-reported by two major media outlets. This is most likely because it is a slow-moving crisis, as opposed to more immediate and seemingly more newsworthy pandemic outbreaks such as COVID-19. In both The New York Times and The Washington Post, pre-COVID-19 coverage of antibiotic resistance focused on it as an isolated pandemic, while coverage after the start of the COVID-19 pandemic typically included antibiotic resistance as a supplemental component of each article, focusing on COVID-19 as the main topic. Using content analysis to assess the coverage of antibiotic resistance, the study found that the vast majority of observed articles provided readers with baseline knowledge and explanation of antibiotic resistance but ultimately failed to characterize the scope, severity, or possible solutions for this important health crisis.

Challenges of Using Publicly-Available Hospital Data to Quantify Health Effects from Wildfire Plumes in the East San Francisco Bay Area Communities of California, USA

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ABSTRACT
In the summer and fall of 2018 and 2020, major wildfires in Northern California (USA) impacted the San Francisco Bay Area. The remote 2018 and 2020 wildfires produced the highest $PM_{2.5}$ concentrations experienced in the Tri-Valley of the East Bay Area during those two years. The Tri-Valley is composed of the San Ramon, Amador, and Livermore Valleys, surrounded by local terrain that creates a small airshed. In 1967, the California Air Resources Board created 15 Air Basins defined by regional geography, topographic and meteorological conditions. Airshed is sometimes synonymous with an urban-scale component of an Air Basin. We use airshed as a Tri-Valley component of the Bay Area Air Basin. This airshed spans across two counties (Contra Costa and Alameda) and encompasses four cities: San Ramon, Dublin, Pleasanton, and Livermore. PurpleAir (PA) sensors provided good geographic coverage of variation in $PM_{2.5}$ in the Tri-Valley airshed. Several studies have established significant health effects from wildfire plumes by associating daily hospital visits with $PM_{2.5}$ air quality data at local and regional scales. We hypothesize that during the wildfire smoke periods of 2018 and 2020 in the Tri-Valley area, there was an increase in hospitalizations and ED visits for respiratory (asthma and COPD-related) health effects, as compared to the same time periods during years with less fire activity. The primary goal of this study was to confirm health effects from wildfire plumes on a community scale using 5 years of publicly-available health data. However, with only monthly hospitalization data available, directly linking respiratory hospital and emergency department (ED) visits with $PM_{2.5}$ concentrations was unsuccessful. Also, because COVID-19 masked all other causes of hospital visits in 2020, that year was ultimately eliminated from this study. However, visits during November 2018 being much higher than any other November in 2016, 2017, and 2019 implied a potential cause and effect. Daily hospitalization and air quality data are required to quantify any relationship by regression analysis. These findings help inform future studies on the health effects of air quality at community scales.

KEYWORDS
$PM_{2.5}$ Air Quality; Air Pollutant Exposure; Air Quality Monitoring; Wildfire Smoke; Respiratory Health; PurpleAir Sensors

INTRODUCTION

Exposure to wildfire smoke very likely increases acute respiratory health effects.[1-3] The negative effects associated with wildfire smoke exposure have become an increasingly pressing issue as California experiences more wildfires. In 2020 alone 3.6 million acres were burned in California and residents were exposed to smoke for many more days than normal.[3] Our study focuses on the San Francisco East Bay Area's Tri-Valley, an airshed within Contra Costa and Alameda counties. The geographic nature (surrounding foothills that can trap pollutants in the valleys during stagnant wind conditions)[1] of Tri-Valley creates the potential for wildfire smoke and associated air pollutants, particularly fine particulate matter ($PM_{2.5}$, particles that are 2.5 microns or smaller in diameter) to settle in the valleys where the cities of San Ramon, Dublin, Pleasanton, and Livermore are located.

In recent years (2018 and 2020), there have been instances where the Tri-Valley has been affected by an influx of wildfire smoke from Northern California wildfires. In 2018, wildfire smoke from the Camp Fire was likely present on 13 of the 15 days when the 24-hour $PM_{2.5}$ federal standard of 35 $\mu g/m^3$ was exceeded in the Tri-Valley that year. The Camp Fire was the "most deadly and destructive"[4] wildfire in California, occurring in the town of Paradise on November 8, 2018, and was fully contained by November 25, 2018.[5] The fire burned 153,336 acres, 19,356 structures, and resulted in 85 deaths.[5] Specific meteorological conditions made the Camp Fire severe. With speeds over 20 mph, hot, dry downslope winds known as Diablo winds caused the fire to not only spread rapidly in Paradise, but they also carried the smoke plume into the Tri-Valley airshed.[6]

In 2020, the Santa Clara Unit (SCU) Lightning Fire Complex burned at the end of summer into fall. The complex of 20 fires first started on August 16 and wasn't fully contained until October 1.[7] The fires burned 396,624 acres,[7] with the two largest fires merging and burning south of Livermore and Pleasanton.[8] In 2020, all 17 $PM_{2.5}$ exceedance days (days where the national standard was exceeded, see explanation in the following paragraph) in the Tri-Valley were probably due to smoke from the Santa Clara Unit (SCU) Lightning Fire Complex entering the area.

The Bay Area Air Quality Management District (Air District) recommends staying indoors during these unhealthy smoke days. Previous studies have found that while indoor $PM_{2.5}$ concentrations are typically lower than outdoor concentrations, indoor concentrations still follow outdoor increases.[9, 10] The Environmental protection agency (EPA) regulates air quality nationwide through their Air Quality System (AQS).[11] The EPA also establishes National Ambient Air Quality Standards (NAAQS), with the annual primary standard for $PM_{2.5}$ being 9 $\mu g\ m^{-3}$.[12]

Low-cost sensors can be used to measure air pollutants at higher spatial and temporal scales than regulatory agency monitoring networks with less operating skill and significantly less cost. While the key advantage of low-cost sensors is their low expense, the major disadvantage is their accuracy. The South Coast AQMD Air Quality Sensor Performance Evaluation Center (AQ-SPEC) reviewed sensor characteristics and performance. In their 2016laboratory and field comparisons, both Purple Air PA-I and PA-II $PM_{2.5}$ sensors were found to correlate with Federal Reference Method (FRM) or Federal Equivalent Method (FEM) sensors with linear correlation coefficients greater than 0.9 for 5-minute data as well as 1-hour averages.[13] Both AQ-SPEC and Barkjohn, et al. (2021) found that the PurpleAir Sensors had good precision but read high by approximately 40%.[13, 14] Wallace, et al. (2022) found that PA-I and PA-II measurements can agree well with regulatory monitors when an optimum calibration factor of 3.4 is applied.[15]

PA, a network of low-cost indoor and outdoor air quality sensors, has been used to observe spatial trends in $PM_{2.5}$ concentrations.[16] The advantages of using the PA sensor network for this study are that there are many sensors that record publicly available data. The number of sensors allows for high spatial coverage of the Tri-Valley area. However, some of the disadvantages of PA are that sensors are set up by the public and inconsistencies in sensor placement can affect data quality. Additionally, sensors can have unreliable/irregular recording, with no or incorrect recordings for periods of time. Widespread use of PA sensors is relatively new, and many sensors were not up and running until after 2018. For these reasons the PA data quality is not the same as quality assured air district monitors (see: http://www.aqmd.gov/aq-spec/home) Comparatively, district sensors (part of the EPA AQS) follow EPA requirements and the data is quality assured and controlled.[11] EPA AQS monitoring stations are likely more accurate than PA sensors for $PM_{2.5}$ data; however, there are more PA sensors than district sensors with 1,171 out of 5,824 census tracts in California having one to two fully operational PA sensors.[17] Compared to the approximately 250 sensors in the California Ambient Air Monitoring Network.[18]

Previous studies have addressed whether or not wildfire smoke and associated $PM_{2.5}$ have significant effects on (respiratory) health outcomes.[2, 19, 20] Recent epidemiological studies have shown that $PM_{2.5}$ from wildfire smoke can exacerbate a range of health problems including respiratory and cardiovascular issues.[2, 19, 21-23] Several studies link wildfire-specific $PM_{2.5}$ exposures to increases in respiratory hospitalizations. Other studies further aim to determine which groups are most affected,[19, 24] while others aim to determine "whether $PM_{2.5}$ from wildfires is more or less harmful [to human health] than PM2.5 from other sources" [25] For instance, Aguilera *et al.* (2021) found that $PM_{2.5}$ from wildfire smoke events in Southern California was up to ten times worse for human health than non-wildfire $PM_{2.5}$ in terms of respiratory hospital admissions.[25]

Another topic of interest in previous studies is the spatial aspect of respiratory health effects; [24, 16] one these studies, Southerland *et al.* (2022), specifically aims to determine if exposure to $PM_{2.5}$ at smaller (city) scales shows a different trend in $PM_{2.5}$ attributable mortality than larger spatial scale studies.[16] This information can give us a better understanding of spatial hotspots of negative health outcomes related to $PM_{2.5}$ exposure, which would allow for targeted mitigation strategies. Typically, the variation in health impacts at finer spatial scales is masked because impacts are generally reported at the country, state, or county level.[16] So, Southerland *et al.* (2022) studied how air pollution-related health risks vary at the neighborhood scale within cities, specifically Bay Area cities, to assist with public health decision making.[16] The researchers determined that pollution-attributable risks can vary considerably within individual cities.[16] Furthermore, neighborhoods with the highest air pollution-attributable health risks were not necessarily those with the highest pollutant concentrations.[16] However, there were limitations to the study in that baseline disease rates are hard to obtain at urban and intra-urban scales.[16] So, for asthma incidence the researchers were only able to use the statewide incidence rate, despite the fact that there is data evidence for spatial variation in asthma incidence in the Bay Area.[16]

A focus of recent studies, relevant to our study, is indoor vs outdoor $PM_{2.5}$ monitoring and exposure. As O'Dell *et al.* (2022) point out, most air quality research is focused on outdoor pollutant concentrations, while people tend to spend more of their time indoors.[10] Using publicly-available data from low-cost sensors, O'Dell *et al.* (2022) found that during periods of heavy smoke,

indoor $PM_{2.5}$ concentrations could exceed the 35 μg m^{-3} 24-hour federal outdoor standard.[10] Also, they found a "total daily-mean indoor $PM_{2.5}$ concentrations increase by 2.1 μg m^{-3} with every 10-μg m^{-3} increase in daily-mean outdoor $PM_{2.5}$."[10] For our study, we utilize PA sensors to look at both indoor and outdoor concentrations across the Tri-Valley. We compare one nearby indoor and outdoor PA sensor to each of the two district sensors during the 2020 wildfire period (Table 1), in order to gain a better understanding of indoor $PM_{2.5}$ concentrations during a wildfire smoke episode, given the amount of time people generally spend indoors. [10]

Some researchers conducting epidemiological studies associated with wildfire smoke have access to non-publicly accessible hospitalization data. For example, Alexeeff *et al.* (2023) used a cohort of 3.7 million adults in the Kaiser Permanente Northern California health care system.[26] From this large dataset they were able to determine that long-term $PM_{2.5}$ exposure was associated with cardiovascular health issues.[26] Both Delfino *et al.* and Aguilera *et al.* obtained their hospitalization data from the California Office of Statewide Health Planning and Development, however, this data was not accessible for this research.[19, 25] One important thing to note about most studies (aside from Alexeeff *et al.*)[26] is that they look at acute health effects resulting from exposure to only one smoke event, rather than considering cumulative health effects from multiple exposure events.[27] This means its possible health impacts are more extensive than reported in these single-event studies.[27] Even with some studies having great accessibility to data, a review by Black *et al.* (2017) notes that there must be a more standardized consensus on both air quality monitoring and reporting during wildfire events in order to allow for more thorough epidemiological, between-study comparisons.[28]

In this paper we aim to gain a better understanding of one, how PA sensor data compare to quality-assured air district monitoring data during normal air quality days as well as days when a wildfire smoke plume is present in the Tri-Valley; and two, the potential respiratory health effects of the 2018 and 2020 wildfire smoke plumes present in the Tri-Valley. Our basic hypothesis is that increases in wildfire smoke $PM_{2.5}$ are correlated with increases in hospitalizations and ED visits for asthma and COPD-related health effects during the 2018 Camp Fire and 2020 SCU Lightning Fire Complex wildfire periods.
We explore this hypothesis with several questions:

1) Are $PM_{2.5}$ concentrations within the Tri-Valley significantly different when a wildfire smoke plume is present versus when one is not?
2) Are PA sensors as accurate as district sensors during typical air quality days and during wildfire smoke days?
3) Is there spatial variation in $PM_{2.5}$ concentrations within the Tri-Valley during a wildfire smoke plume?
4) Can a regression analysis of monthly hospitalization and ED data and monthly $PM_{2.5}$ concentrations be used to evaluate wildfire effects on respiratory health, and if so, is there a significant increase in respiratory hospitalizations and ED visits during wildfire smoke plumes?

METHODS AND PROCEDURES

The geographic area of focus for this paper is the Tri-Valley Airshed, encompassing the cities of Livermore, Pleasanton, and San Ramon, and Dublin as shown in **Figure 1**. The PA sensor network in the Tri-Valley Airshed was used in combination with Air District sensors, which are a part of the EPA AQS,[11] to evaluate changes in $PM_{2.5}$ concentrations across wildfire years and years with less wildfire activity from 2016 to 2020, and potential associations with respiratory hospitalizations and emergency department (ED) visits. The goal was to determine how exposure to $PM_{2.5}$ from the 2018 Camp Fire and the 2020 Lightning Fire Complex impacted the health of Tri-Valley residents.

$PM_{2.5}$ and hospitalization data

The period of study from 2016 to 2020 encompasses the Camp Fire in 2018 and the SCU Lightning Complex Fires in 2020. $PM_{2.5}$ data was collected from two sources. First, quality-assured Air District data was downloaded from the EPA AirNow website from the Pleasanton and Livermore Air District monitoring stations. The Pleasanton $PM_{2.5}$ monitor is a Special Purpose Monitor (SPM) and a Federal Equivalent Method (FEM) monitor.[29] Specifically it is a FEM BAM 1020 monitor manufactured by Met One.[29] The Livermore $PM_{2.5}$ monitor, on the other hand, is a State or Local Air Monitoring Station (SLAMS) and a FEM monitor.[29] Like the Pleasanton station it is a FEM BAM 1020 manufactured by Met One.[29] Second, $PM_{2.5}$ data was downloaded from the publicly available low-cost sensor PA website using an API key provided along with Python code. PA sensors in the study area began recording data at different dates from 2018 to 2020 posing limitations for this analysis. **Figure 2** shows the PA sensors in the Tri-Valley available on September 28, 2020. Less than half of these stations were operating in 2018. This, along with the fact that PA sensors are deployed by users in the public are serious limitations in terms of the quality of data generated by these sensors. The PA data collected was _atm data for outdoor sensors and cf_1 data for indoor sensors. Cf_1 and cf_atm are "formulas used in Plantower laser counters" which are the mechanics that make up the PA sensors.[30] Cf_1 and cf_atm data have a proprietary correction factor formula automatically applied to it in order to compensate for different conditions outdoors versus indoors.[30] A previous study conducted by Barkjohn *et al.* (2022) used cf_1 data because it is more strongly correlated to reference monitors than cf_atm data.[31]

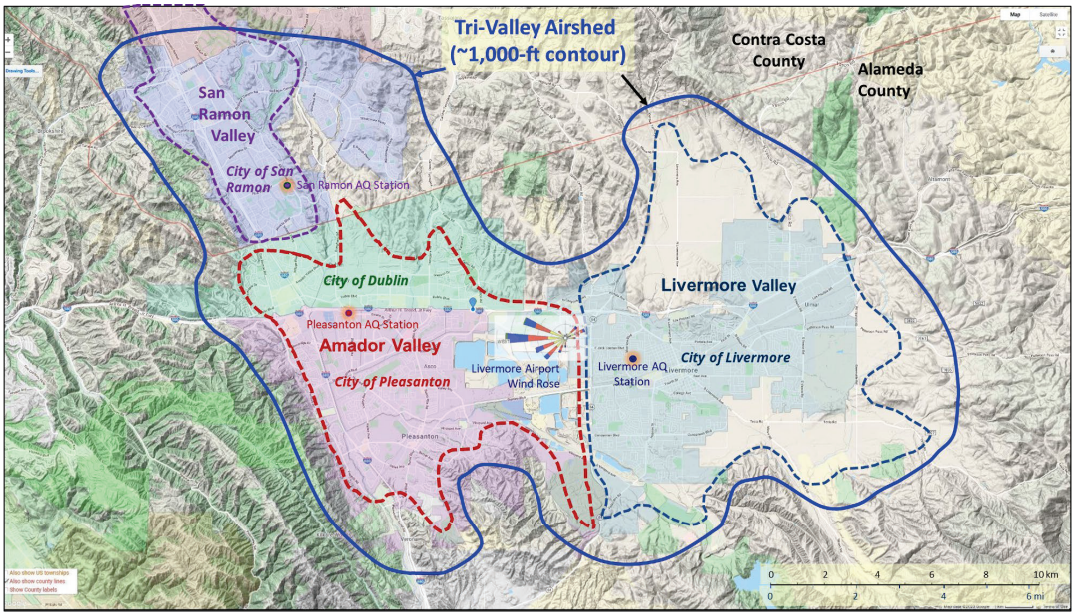

Figure 1. Tri-Valley Airshed in Contra Costa and Alameda counties in California, defined by the 1,000-ft contour (solid blue line) surrounding the San Ramon, Amador, and Livermore Valleys with valley floors depicted as dashed lines. The three BAAQMD Stations are noted as well as the annual wind rose at the Livermore Airport. (Created from Google Maps base)

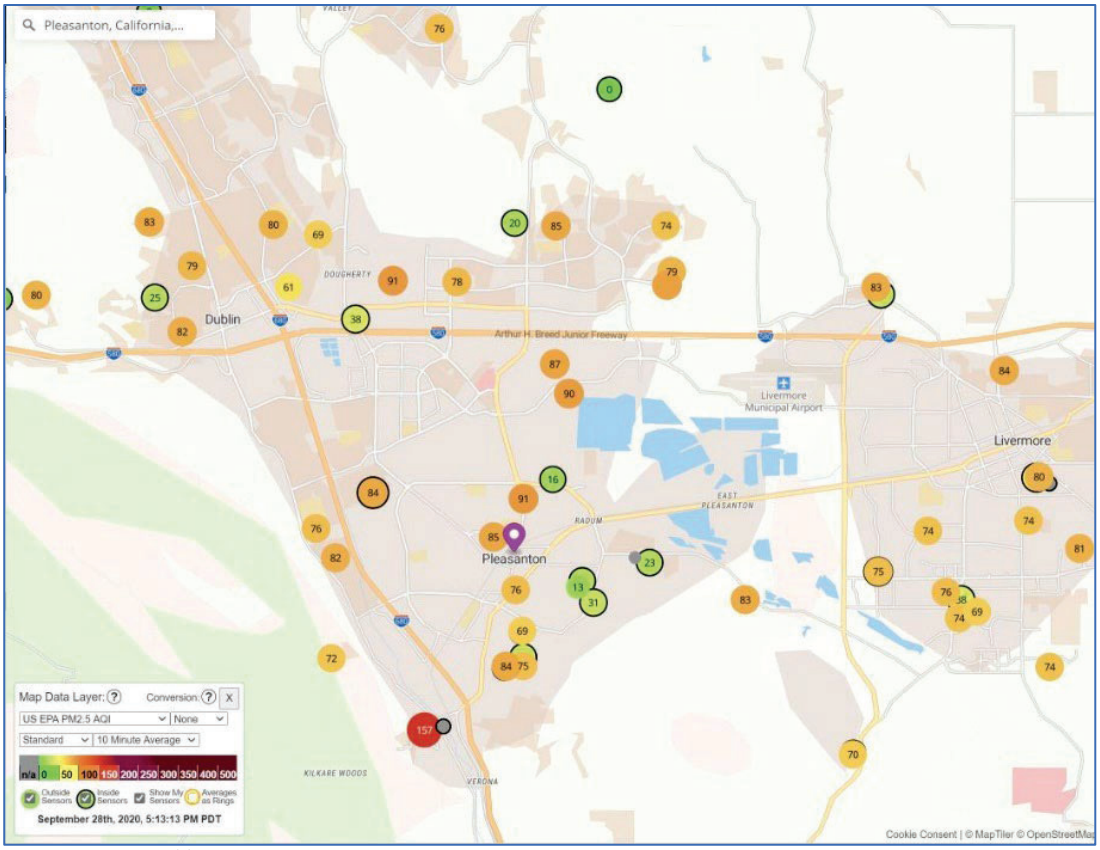

Figure 2. PurpleAir sensors in the Tri-Valley on September 28, 2020. Indoor stations are indicated with a solid black line around the station circle. For PurpleAir stations and their names used in this study, see **Figure 8.**

While accessing $PM_{2.5}$ data was relatively easy, gathering of hospital admissions data involved more effort and time (almost two months) and was a key learning experience of this study. The process began with reviewing previous wildfire health effect studies with County Health Department epidemiologists to select the relevant International Classification of Diseases 10 Clinical Modification (ICD 10 CM) codes that could distinguish smoke health effects. Since the Tri-Valley Airshed encompasses two counties, both Alameda County Public and Contra Costa County Health Departments were involved.

After several iterations, the final request involved epidemiologists from the two counties to write and execute scripts to download data from the California Department of Health Care Access and Information (HCAI) Patient Discharge Data and Emergency Department data:

- For asthma ICD 10 CM codes J45[2-5] [0-2], J459 plus COPD code J4[0-4] combined.
- Monthly by zip code each year from 2016 through 2020.
- By age groups <18, 18-44, 45-64, 65+, and total.

The expectation that sufficient daily visit data would be available for the four communities was not met. Instead, due to the small numbers and the requirement to maintain anonymity, monthly data were provided. Even with monthly totals, the number of visits occasionally was less than 11 and was denoted as <11 for anonymity.

Confirming periods when wildfire smoke was present in the Bay Area

Four tests were conducted to evaluate the difference between $PM_{2.5}$ levels during the 2018 and 2020 fire events and typical seasonal $PM_{2.5}$. The year 2019 was used as a control because based on reviewing daily NASA WorldView satellite imagery, no smoke plumes were found to enter the Bay Area that year. Other major wildfires during the study period include the September 2018 Walker Fire and the October 2019 Kincade Fire. However, NASA WorldView satellite imagery showed that the smoke from the Walker Fire located in the Sierra Mountains east of Chico was driven directly eastward and the plume from the Kincade Fire in Sonoma County went offshore to the west. The Bay Area escaped both plumes.

Four tests were run using Air District $PM_{2.5}$ data. The first test compares the Livermore Air District data from August 16, 2020, until October 8, 2020, to the same period in 2019. For the second test, the same time periods (August 16, 2020, through October 8, 2020, versus August 16, 2019, through October 8, 2019) are compared, but for the Pleasanton Air District sensor. The third test compares the Livermore sensor data from November 9, 2018, until November 27, 2018, to the same period in 2019. For the final test, the same November time periods are compared, but for the Pleasanton Air District sensor. The test periods were selected based on fires with the highest smoke impact from 2016 to 2020; years before 2016 were not included based on hospitalization and ED visit data availability.

Previous studies have used dispersion modeling to determine when the $PM_{2.5}$ increases were due to wildfire smoke plumes. In lieu of modeling the smoke trajectory, we initially selected days from known wildfires in the vicinity and narrowed the periods based on elevated $PM_{2.5}$ data. To independently select days when wildfire smoke was present over the Tri-Valley, we reviewed NASA WorldView satellite imagery. For the periods of interest, we viewed the daily Visible Infrared Imaging Radiometer Suite (VIIRS) Corrected Reflectance imagery taken by the VIIRS instrument aboard the joint NASA/NOAA NOAA-20 (JPSS-1) satellite. We included the VIIRS Fire and Thermal Anomalies layer which indicates active fire detections and thermal anomalies, such as volcanoes, and gas flares.

Figure 3 shows that while the Camp Fire was located over 150 miles from the Tri-Valley, strong Diablo winds from the northeast blew the smoke plume into the Tri-Valley Airshed. **Figure 4** plots the daily Air Quality Index (AQI) data taken in the Tri-Valley. (Note: An AQI of 100 represents 100% of the concentration of the associated federal standard.) **Figure 5** shows that the SCU Fires were much closer to the Tri-Valley. During the SCU Complex, the smoke plume enveloped the Tri-Valley Airshed with mean daily $PM_{2.5}$ AQI reaching 140 to 158 during three heavy smoke periods (**Figure 6**). On the first day of these three periods, ozone also was near or above the federal standard. Ozone has been found to be generated in wildfire plumes.[32] With its greater distance, ozone was only half the standard during the Camp Fire.

Figure 3. Satellite image of Camp Fire smoke on November 11, 2018. Source: NASA WorldView.

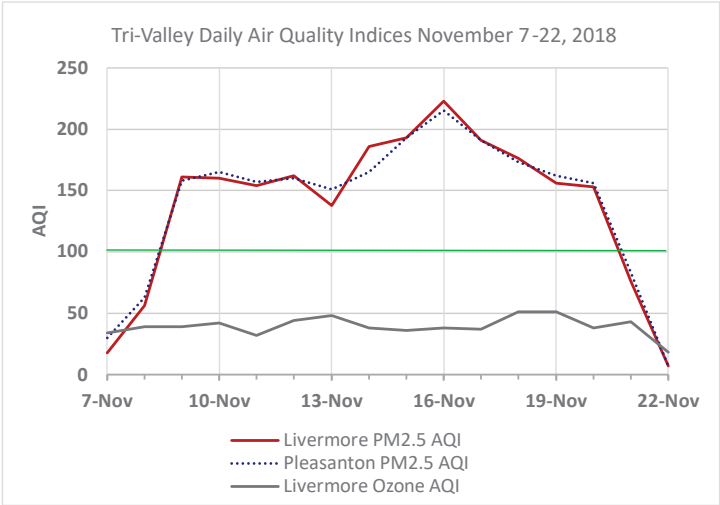

Figure 4. Daily ozone and $PM_{2.5}$ AQI at the Air District Pleasanton and Livermore stations from November 7-22, 2018. The green line (an AQI of 100) represents 100% of the concentration of the associated federal standard. Data Source: EPA AirData.

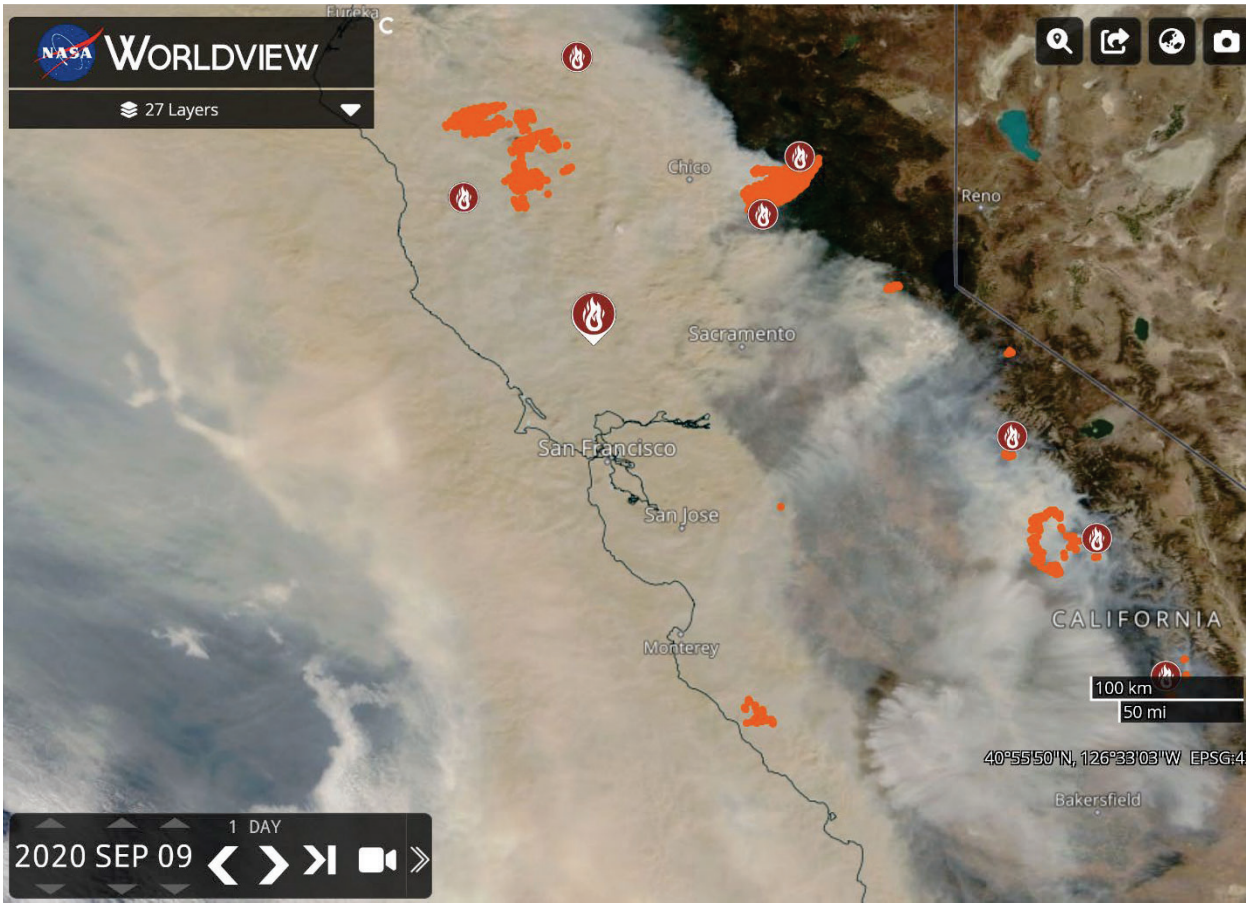

Figure 5. Satellite image of SCU Lightning Fire Complex on September 9, 2020. Source: NASA WorldView.

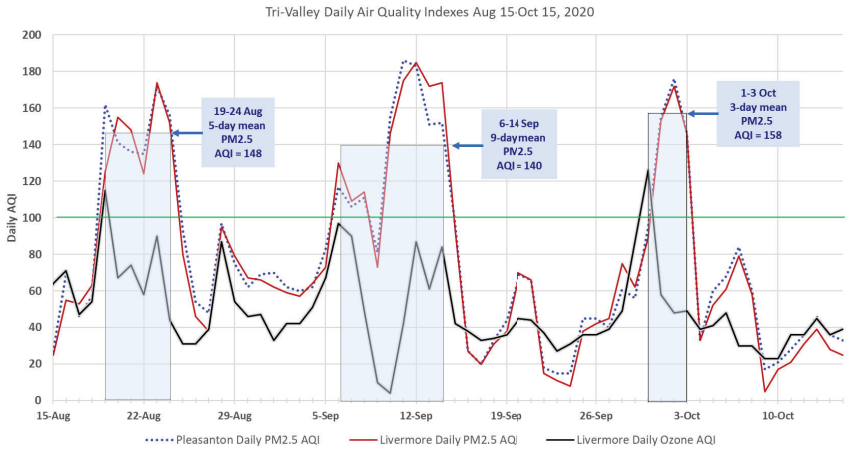

Figure 6. Daily ozone and $PM_{2.5}$ AQI at the Air District Pleasanton and Livermore stations from August 15 to October 15, 2020. The green line (an AQI of 100) represents 100% of the concentration of the associated federal standard. Data source: EPA AirData.

Correlation between PurpleAir and Air District sensors

PA sensors near to a quality-assured Air District monitor were compared to determine if a correlation exists. With this test we aim to understand if PA sensors in the Tri-Valley record at a similar precision and accuracy to Air District monitoring stations during periods where no wildfire smoke is present and during periods where wildfire smoke is present. However, this analysis requires some assumptions including that the district station and the PA sensor are under the similar conditions such as elevation, wind

direction, as well as potential interference from surrounding manmade structures and that there are no other nearby point sources of $PM_{2.5}$ emissions. Sensor data from 2019 and 2020 were used for this comparison because more PA sensors were available closer to Air District stations than previous years. $PM_{2.5}$ data (both Air District and PA) was not collected past 2020, because respiratory hospitalizations and ED visits data was only available up until 2020. The closest outdoor sensor to the Livermore Air District station is the Valley Montessori sensor at 1.4 km (0.88 mi) away. The indoor sensor near the Livermore Air District station is the Heligan Lane PA sensor 2.6 km (1.62 mi) away. The outdoor PA sensor used for the Pleasanton Air District sensor is the James Dougherty Elementary School sensor 2.0 km (1.25 mi) away. And lastly, the indoor sensor used for the Pleasanton Air District sensor is the Dublin Mazda sensor at 0.5 km (0.33 mi) away. For a visual representation of sensor locations, please refer to **Figure 8**. Accuracy of the PA sensors was determined by linear regression, t-tests, and confidence intervals. These tests reveal if the average PA measurements are the same as the average Air District measurements, and if not, they reveal which sensor average is larger.

Geographical variation of $PM_{2.5}$ across the Tri-Valley during wildfire episodes

Another goal of the study was to determine how air quality varies across the Tri-Valley during wildfire episodes. To assess this, average $PM_{2.5}$ concentrations of 12 sensors across the Tri-Valley from August 16, 2020, to October 8, 2020, were computed.

Comparison of monthly average $PM_{2.5}$ with monthly hospitalizations data

This study's main goal was to quantify the association between monthly respiratory hospitalizations and $PM_{2.5}$ via linear regression analysis. We also stratified the analyses by age range. The original plan was to compare hospitalization and ED data with PA sensors for each ZIP code, however the hospital data at the ZIP code scale were not sufficient to perform this analysis. We explored using other respiratory conditions in addition to asthma and COPD, however the County Health Departments explained that using pneumonia and bronchitis would likely be too complicated due to noise from non-wildfire factors. Also, because respiratory hospitalizations in 2020 were almost all due to COVID-19, that year's data was not usable. The key limitations associated with the publicly-available hospitalization data were that only monthly totals were available, 2020 was not useable due to COVID-19, and hospitalizations of 11 or lower were recorded as <11 (for computations, values recorded as <11 were set to 11)

RESULTS

Hypothesis test and confidence intervals for periods when wildfire plumes were present versus absent

Overall, results were as expected—both the 2018 and 2020 fire period had higher average $PM_{2.5}$ concentrations than 2019 for both Livermore and Pleasanton (**Figure 7**.) The confidence intervals at 95% for the 2018 fire period versus the 2019 non-wildfire plume period, for both Livermore and Pleasanton, revealed that the wildfire influenced period mean $PM_{2.5}$ is greater than the non-fire period mean by 31.47 to 74.52 $\mu g/m^3$ and by 31.38 to 71.91 $\mu g/m^3$ respectively.

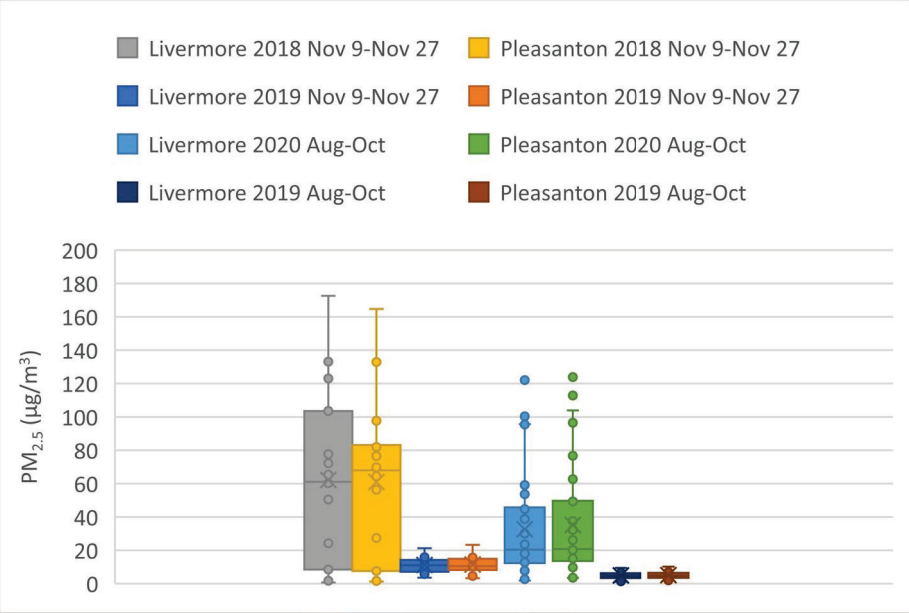

Figure 7. Comparison of the daily mean $PM_{2.5}$ concentrations at the two Air District stations (Livermore and Pleasanton) for the Camp Fire period, SCU Lightning Fire Complex period, and the associated time spans during 2019, when wildfire smoke was not present.

The 95% confidence intervals for the August through October 2020 fire period versus the 2019 non-fire period for both Livermore and Pleasanton revealed that the 2020 fire period mean $PM_{2.5}$ is greater than the 2019 non-fire period mean by 20.91 to 34.46 μg/m³ and by 22.5 to 37.57 μg/m³ respectively. In summary, $PM_{2.5}$ concentrations in Pleasanton and Livermore are on average significantly higher during the wildfire periods studied than the non-wildfire periods studied.

Correlation between PurpleAir and Air District sensors

Figure 8 shows the 12 PA outdoor sensors available in the Tri-Valley in 2019-2020 with their average concentrations during the 2020 SCU Lightning Fire Complex period. The closest outdoor and indoor PA sensor near each Air District sensor was selected to evaluate the accuracy of PurpleAir sensors. Note that different periods of record were available for each of the PA sensors. During the 2020 SCU Lightning Fire Complex period (August 16 to October 8, 2020), the average $PM_{2.5}$ concentration from the 12 sensors ranged from 30.64 to 51.15 μg/m³. The lowest $PM_{2.5}$ readings occurred at Valley Montessori School, Aspen Court, and Pasatiempo, likely due to sporadic missing data from August 16 through September 2, 2020. We were unable to conduct a similar analysis for the 2018 wildfire period because there was only one PA sensor recording at that time. Additionally, this sensor (Castlewood) had erroneous recordings, recordings that were outside the range of possible $PM_{2.5}$ recordings, such as readings over 1,000, and was therefore eliminated from the study. These erroneous values occurred both during periods when a wildfire smoke plume was present in 2020 and when one wasn't present in 2019.

Figure 8. The red dots show the 12 PurpleAir sensors used to evaluate $PM_{2.5}$ concentrations across the Tri-Valley. The size of the red dots represents the range in average $PM_{2.5}$ concentrations during the 2020 SCU Lightning Fire Complex period (August 16 to October 8, 2020). Note that the data used for this map is cf_1 data.

Sensor	Mean $PM_{2.5}$ (μg/m³)
Livermore Air District	32.57
Pleasanton Air District	35.16
James Dougherty	45.20
JM Amador	46.54
Dublin Onyx	49.80
Dublin Mazda (indoor)	33.93
Los Alamos	43.02
Lucca Circle	47.39
Mine*	47.78
Chateau PL*	38.75
Chardonnay	43.11
Pleasanton Hills	51.15
Heligan Lane (indoor)	11.67
Valley Montessori*	33.59
Aspen Court*	42.77
Pasatiempo*	30.64

Table 1. Mean $PM_{2.5}$ readings from Air District sensors, as well as PA sensors for the 2020 wildfire period (August 16, 2020 – October 8, 2020, except where noted with an asterisk). Sensors with an asterisk (*) had less data points (days with recordings) available and only began recording as early as September 1, 2020. Rows highlighted in grey represent the four PA stations that are compared to the Air District stations.

Air District (AD) Station	Nearest PurpleAir (PA) Station	Distance between Stations (km)	Coefficient of Determination (r^2)	Comparison of $PM_{2.5}$ Mean Values	95% Confidence Interval ($\mu g/m^3$)
Livermore	Valley Montessori (outdoor)	1.4	0.57	PA>AD	5.13 to 12.36
	Heligan Lane (indoor)	2.6	0.43	AD>PA	4.2 to 6.7
Pleasanton	James Dougherty (outdoor)	2.0	0.64	PA>AD	2.26 to 5.81
	Dublin Mazda (indoor)	0.5	0.79	AD>PA	3.35 to 5.57

Table 2. Correlation between Air District and PurpleAir $PM_{2.5}$.

Supplemental Figure 1 shows that the outdoor Valley Montessori PA sensor was moderately correlated to the nearby Livermore Air District sensor with a linear regression r-squared of 0.57. The confidence interval revealed at the 95% confident level the Valley Montessori PA sensor data is on average greater than the Air District sensor data by 5.13 to 12.36 $\mu g/m^3$. Delp *et al.* found a similar trend in PA II readings overpredicting $PM_{2.5}$ concentrations during the Camp Fire across Northern California.[33] Furthermore, these researchers found that an adjustment factor of 0.48 could make PA II readings more accurate for the Camp Fire in Northern California.[33] **Supplemental Figure 2** shows that the r-squared was reduced by 0.065 when only looking at the 7-week wildfire period compared to looking at the four-months from September to December 2020. Assuming the Livermore Air District readings are the accurate readings, the difference between the PA and Air District mean for each period gives a rough indicator for which period the PA readings are more accurate. During the entire period (September 2, 2020, to December 31, 2020) the mean difference between the Valley Montessori PA sensor and the Livermore Air District sensor was 8.7, whereas during the SCU Wildfire period the mean difference was 1.0, implying the Valley Montessori PA sensor was more accurate during just the SCU Wildfire period.

Both PA sensors in Pleasanton showed a good correlation with the Pleasanton Air District station. The James Dougherty Elementary outdoor sensor provided a reasonably good estimate of the Air District sensor with an r-squared of 0.64 (**Supplemental Figure 4**) We are 95% confident the true mean $PM_{2.5}$ of the James Dougherty sensor was greater than the Air District sensor by 2.26 to 5.81 $\mu g/m^3$. This suggests that the James Dougherty sensor recorded higher $PM_{2.5}$ levels than the Air District sensor on average despite their strong correlation. The Lane Regional Air Protection Agency found similar results when looking at PA sensors in their airshed in Oregon. They found that even though the PA sensors showed low accuracy to the reference monitors, they showed high precision with consistent overpredictions at double the reference monitor recordings.[34] When comparing **Supplemental Figure 4** and **Supplemental Figure 5**, the proportion of statistical variation of the James Dougherty Elementary PA sensor readings that can be explained by the Pleasanton Air District remains approximately the same between the SCU Wildfire period (August 16, 2020 to October 8, 2020) and the entire period studied (September 16, 2019, to December 31, 2020) This is supported by similar r-squared values of approximately 0.64 for both periods. Because the PA sensor mean is only approximately 4 points different than the Air District mean during the entire period, but 10 points different during the SCU Wildfire period, the PA sensor is likely less accurate during the SCU Wildfire.

Supplemental Figure 3 shows that the Heligan Lane indoor PA sensor was weakly correlated with the nearby Livermore Air District sensor with an r-squared of 0.426. The two-sample mean hypothesis test between the Heligan Lane indoor PA sensor, and the Livermore Air District sensor yielded a p-value of 4.76×10^{-13} which means there is statistically significant evidence that the two means are not the same. The confidence interval revealed at the 95% confident level the Air District sensor is on average 4.2 to 6.7 $\mu g/m^3$ greater than the Heligan Lane sensor. This is likely due to improved air quality indoors as the result of HVAC and air filtration systems.
On the contrary, **Supplemental Figure 6** illustrates that the indoor Dublin Mazda Pleasanton PA sensor showed strong correlation with an r-squared of 0.79, but the t-test showed the Air District sensor had higher concentrations on average. The t-test yielded a p-value of 2.69×10^{-11}. This t-test shows 95% confidence that the Pleasanton Air District sensor was on average greater than the Dublin Mazda sensor by 3.35 to 5.57 $\mu g/m^3$. The HVAC system plays a role in reducing indoor concentrations.

Comparison of monthly average $PM_{2.5}$ with monthly hospitalization data
The main takeaway from comparing $PM_{2.5}$ and Asthma and COPD hospitalizations is that there are serious limitations to statistical comparisons at this temporal scale. Monthly data going back only five years doesn't seem to be enough to draw

definitive conclusions with respect to the present study data, especially when the 2020 data was unusable due to the confounding effects of COVID-19.

Due to the 2020 hospitalization and ED data being affected by COVID-19, only the November 2018 fire period was available for analysis of wildfire effects. **Figure 9** shows the combined monthly average $PM_{2.5}$ from the two Air District sensors in Livermore and Pleasanton was not correlated with the monthly hospitalizations and ED visits for asthma and COPD for May through December 2018. This is likely because there is not enough data. If, for example, monthly November hospitalizations for many more years were used, better results might be possible to show whether or not respiratory ED and hospital visits are correlated with $PM_{2.5}$. Also, using individual months limits the variability associated with seasonality that occurs throughout the year. However, **Figure 10** reveals that both hospitalizations plus ED visits and $PM_{2.5}$ peaked in November 2018 during the Camp Fire. A simple line plot doesn't allow for a definitive correlation like a regression analysis does, but it does visualize the phenomena of hospitalizations/ED visits for respiratory issues increasing when $PM_{2.5}$ from wildfire smoke also increases.

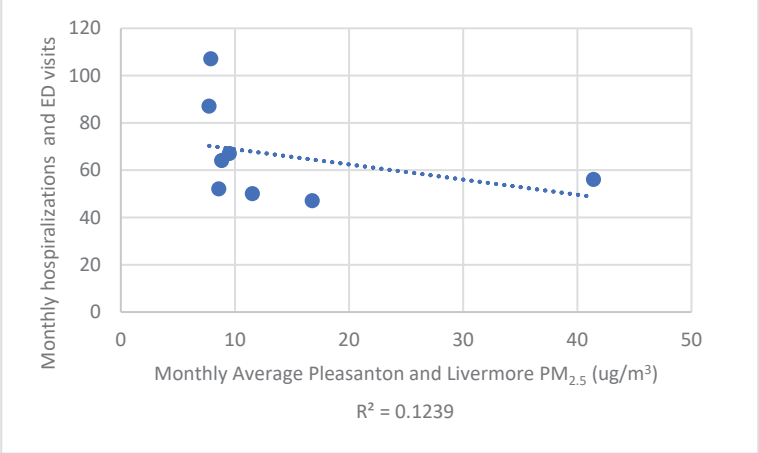

Figure 9. Monthly Average $PM_{2.5}$ from combined Air District sensors versus total monthly respiratory (asthma and COPD) hospitalizations and ED visits for May through December 2018.

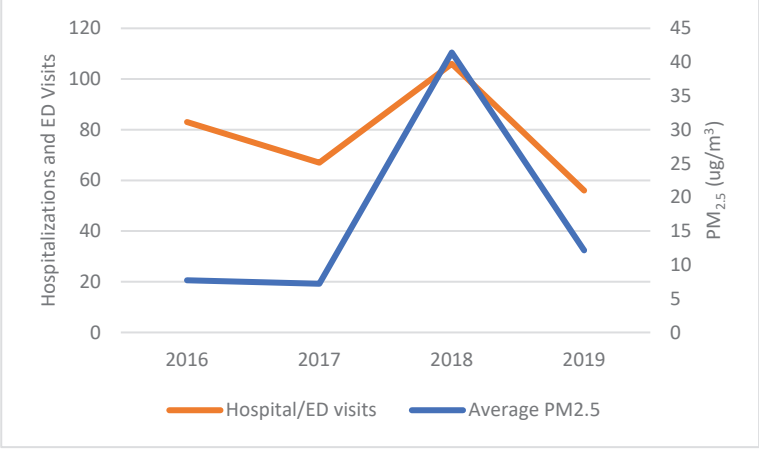

Figure 10. November Hospitalizations and ED visits plotted with average November $PM_{2.5}$ for 2016 through 2019. There is a notable spike in both $PM_{2.5}$ and respiratory hospitalizations and ED visits in November 2018 when the Camp Fire occurred.

DISCUSSION

Confirming periods when wildfire smoke was present in the Bay Area While the wildfires of 2018 and 2020 were located some distance from the Tri-Valley, hypothesis tests confirmed that dramatic $PM_{2.5}$ increases did occur in the Tri-Valley from these remote wildfires.

Correlation between PurpleAir and Air District sensors

The hypothesis tests and linear regressions between the PA sensors and Air District monitors confirmed that PA are moderately to strongly correlated with the Air District monitors for $PM_{2.5}$ recordings across the Tri-Valley. Based on previous literature, PA sensors overestimate $PM_{2.5}$ concentrations during periods of high concentrations, such as wildfires.[35, 31] Two recent studies found

that the low-cost sensors were moderately to strongly correlated with the reference instrument, but that they overpredicted concentrations.[36, 33]

In this study, the linear regression between the outdoor Livermore PA sensor and the Livermore Air District sensor revealed a moderate correlation. However, it is interesting to note that the lower values seem to follow a linear trend, while the higher values do not. There was also a moderate relationship between the indoor Livermore PA sensor and the Air District sensor, with an r-squared value of 0.43. It was expected that the indoor PA sensor would be less correlated with the Air District sensor than the outdoor one.

The regression between the Pleasanton PA and the Pleasanton Air District outdoor sensors showed evidence for a strong linear relationship with an r-squared value of 0.64. It's interesting to note that the Air District sensor is located adjacent to the freeway, while the PA sensor, the James Dougherty Elementary sensor, is not located quite as close. It's also interesting that there is a strong correlation between the Air District and PA sensors in Pleasanton, but not necessarily for Livermore—especially when the Pleasanton James Dougherty sensor was farther away from its Air District sensor than the Livermore Valley Montessori sensor from its Air District sensor.

For both outdoor PA sensors, the mean difference between the PA sensor and the Air District sensor was compared for the entire period studied to just the SCU wildfire period to establish a rough indication of when the PA sensor is more accurate. There were conflicting results as the Livermore Valley Montessori PA sensor seems to be more accurate during the SCU Wildfire period and the Pleasanton James Dougherty PA sensor seems to be less accurate during the SCU Wildfire period. It was expected that both sensors would be less accurate during the SCU Wildfire period due to the higher concentrations of $PM_{2.5}$. However, there are confounding factors (such as a sensor that was misplaced/not working correctly, at one point, being fixed) that may be responsible for this discrepancy, along with the fact that comparing mean difference is only a rough indication for accuracy.

Another important finding is that the indoor Pleasanton sensor (Dublin Mazda) has a strong linear relationship with the Pleasanton Air District sensor with an r-squared value of 0.79. This is the strongest linear relationship of all four regressions conducted. This is likely because the Dublin Mazda sensor is so close to the Pleasanton Air District sensor (0.5 km apart), the closest out of all four sensors. Thus, the proximity of the sensors would explain the close correlation in the readings between the indoor PA sensor and outdoor Air District sensor, despite the fact one is indoors and the other is outdoors. Another plausible explanation for the strong linear relationship is that there is a lot of outdoor air flowing through the Dublin Mazda center. It could also be possible that the sensor was incorrectly labeled as indoor when it is actually located outdoors. A visit to the location could not confirm the sensor location.

Association between monthly average $PM_{2.5}$ and monthly hospitalization data

Because of the limitations to monthly hospital data, conclusions about the correlation between wildfire $PM_{2.5}$ and respiratory hospitalizations and ED visits in the Tri-Valley are not possible. Linear regression revealed no correlation between monthly $PM_{2.5}$ and hospital and ED visits. Previous studies were successful in quantifying the association between health effects and elevated $PM_{2.5}$ due to wildfires. For example, a study on the respiratory health effects of Northern California fires in 2008 found a "linear increase in risk for asthma hospitalizations… and asthma ED visits…with increasing $PM_{2.5}$ during the wildfires" with a risk ratio of 1.07.[2] Our current study's results don't match this trend due to our study area being much smaller (making the sample size even smaller), as well as only having access to monthly data and only for a five-year period.

CONCLUSIONS

Our study confirmed increases in $PM_{2.5}$ concentrations in the Tri-Valley during 2018 and 2020 wildfire episodes were statistically significant. When compared to BAAQMD sensors, low-cost PA sensors in the Tri-Valley were more accurate at lower concentrations, as previous studies had suggested. There was little variation in $PM_{2.5}$ across the Tri-Valley during the SCU wildfire episodes, but all sensors recorded average $PM_{2.5}$ concentrations above the federal standard daily average. Using regression analysis for monthly hospitalization, ED data, and monthly $PM_{2.5}$ concentrations is not adequate for evaluating wildfire effects on respiratory health. Daily hospitalization and air quality data are likely needed for future studies to quantify their relationship by regression analysis. These findings help inform future studies on air quality at community scales.

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Views and conclusions are those of the authors.

REFERENCES

1. Tri-Valley Air Quality Climate Alliance. (2023, November 1) *Tri-Valley airshed: What is it? https://tvaqca.org/?page_id=102*
2. Reid, C. E., Jerrett, M., Tager, I. B., Petersen, M. L., Mann, J. K., & Balmes, J. R. (2016)) Differential respiratory health effects from the 2008 Northern California wildfires: A spatiotemporal approach. *Environmental Research*, *150*, 227–235. *https://doi.org/10.1016/j.envres.2016.06.012*
3. Melvin, A. (2022) In *Wildland fires: Toward improved understanding and forecasting of air quality impacts*. Washington, DC; National Academies Press.
4. Baldassari, E. (2018, November 11) Camp fire death toll grows to 29, matching 1933 blaze as state's deadliest. *East Bay Times*.
5. U.S. Department of Commerce and Zimmerman, J. (2020) *Service Assessment, November 2018 Camp Fire*. Salt Lake City, Utah: National Weather Service.
6. Brewer, M. J., & Clements, C. B. (2019) The 2018 Camp Fire: Meteorological analysis using in situ observations and numerical simulations. *Atmosphere*, *11*(1), 47. *https://doi.org/10.3390/atmos11010047*
7. Borsum, D., & Plouffe, K. (2022, March 13) *SCU Lightning Complex, Central California.* ArcGIS StoryMaps. *https://storymaps.arcgis.com/stories/1ee955466a484d*^{0}*950c28b57476bd65*
8. Walsh, J. (2020, August 22) Two major SCU lightning complex fires merge south of Tri-Valley. *Pleasanton Weekly*. Retrieved September 21, 2023, from *https://pleasantonweekly.com/news/2020/08/22/two-major-scu-lightning-complex-fires-merge-south-of-tri-valley*.
9. Kramer, A. L., Liu, J., Li, L., Connolly, R., Barbato, M., & Zhu, Y. (2023) Environmental justice analysis of wildfire-related $PM_{2.5}$ exposure using low-cost sensors in California. *The Science of the total environment*, *856*(Pt 2), 159218. *https://doi.org/10.1016/j.scitotenv.2022.159218*
10. O'Dell, K., Ford, B., Burkhardt, J., Magzamen, S., Anenberg, S. C., Bayham, J., Fischer, E. V., & Pierce, J. R. (2022)) Outside in: The relationship between indoor and outdoor particulate air quality during wildfire smoke events in western US cities. *Environmental Research: Health*, *1*(1), 015003. *https://doi.org/10.1088/2752-5309/ac7d69*
11. Environmental Protection Agency. (2024, January 22) *Managing Air Quality - Ambient Air Monitoring.* EPA. *https://www.epa.gov/air-quality-management-process/managing-air-quality-ambient-air-monitoring*
12. Environmental Protection Agency. (2024b, March 6) *National Ambient Air Quality Standards (NAAQS) for PM*. EPA. *https://www.epa.gov/pm-pollution/national-ambient-air-quality-standards-naaqs-pm*
13. Air Quality Sensor Performance Evaluation Center, Polidori, A., Papapostolo, V., Zhang, H., (2016, August) Laboratory Evaluation of Low-Cost Air Quality Sensors
14. Barkjohn, K. K., Gantt, B., & Clements, A. L. (2021) Development and application of a United States-wide correction for $PM_{2.5}$ Data collected with the PurpleAir sensor. *Atmospheric Measurement Techniques*, *14*(6), 4617–4637. *https://doi.org/10.5194/amt-14-4617-2021*
15. Wallace, L., Zhao, T., & Klepeis, N. E. (2022) Calibration of purpleair pa-I and PA-II monitors using daily mean PM2.5 concentrations measured in California, Washington, and Oregon from 2017 to 2021. *Sensors*, *22*(13), 4741. *https://doi.org/10.3390/s22134741*
16. Southerland, V. A., Brauer, M., Mohegh, A., Hammer, M. S., van Donkelaar, A., Martin, R. V., Apte, J. S., & Anenberg, S. C. (2022) Global Urban Temporal Trends in fine particulate matter (PM2·5) and attributable health burdens: Estimates from Global Datasets. *The Lancet Planetary Health*, *6*(2) *https://doi.org/10.1016/s2542-5196(21)00350-8*
17. Sun, Y., Mousavi, A., Masri, S., & Wu, J. (2022) Socioeconomic disparities of low-cost air quality sensors in California, 2017–2020. *American Journal of Public Health*, *112*(3), 434–442. *https://doi.org/10.2105/ajph.2021.306603*
18. *California Air Resources Board.* Ambient Air Monitoring - Regulatory | California Air Resources Board. (n.d.) *https://ww2.arb.ca.gov/our-work/programs/ambient-air-monitoring-regulatory*
19. Delfino, R. J., Brummel, S., Wu, J., Stern, H., Ostro, B., Lipsett, M., Winer, A., Street, D. H., Zhang, L., Tjoa, T., & Gillen, D. L. (2009) The relationship of respiratory and cardiovascular hospital admissions to the Southern California wildfires of 2003. *Occupational and Environmental Medicine*, *66*(3), 189–197. *https://doi.org/10.1136/oem.2008.041376*
20. Kiser, D., Metcalf, W. J., Elhanan, G., Schnieder, B., Schlauch, K., Joros, A., Petersen, C., & Grzymski, J. (2020) Particulate matter and emergency visits for asthma: A time-series study of their association in the presence and absence of wildfire smoke in Reno, Nevada, 2013-2018. *Environmental Health: A Global Science Source. https://doi.org/10.21203/rs.2.21450/v1*
21. Gan, R. W., Ford, B., Lassman, W., Pfister, G., Vaidyanathan, A., Fischer, E., Volckens, J., Pierce, J. R., & Magzamen, S. (2017) Comparison of wildfire smoke estimation methods and associations with cardiopulmonary-related hospital admissions. *GeoHealth*, *1*(3), 122–136. *https://doi.org/10.1002/2017gh000073*

22. Liu, J. C., Wilson, A., Mickley, L. J., Dominici, F., Ebisu, K., Wang, Y., Sulprizio, M. P., Peng, R. D., Yue, X., Son, J.-Y., Anderson, G. B., & Bell, M. L. (2017) Wildfire-specific fine particulate matter and risk of hospital admissions in urban and rural counties. *Epidemiology*, *28*(1), 77–85. *https://doi.org/10.1097/ede.0000000000000556*
23. Stowell, J. D., Geng, G., Saikawa, E., Chang, H. H., Fu, J., Yang, C.-E., Zhu, Q., Liu, Y., & Strickland, M. J. (2019) Associations of wildfire smoke PM2.5 exposure with cardiorespiratory events in Colorado 2011–2014. *Environment International*, *133*, 105151. *https://doi.org/10.1016/j.envint.2019.105151*
24. Leibel, S. (2019) Increase in pediatric respiratory visits associated with wildfires in San Diego County. *Journal of Allergy and Clinical Immunology*, *143*(2) *https://doi.org/10.1016/j.jaci.2018.12.071*
25. Aguilera, R., Corringham, T., Gershunov, A., & Benmarhnia, T. (2021) Wildfire smoke impacts respiratory health more than fine particles from other sources: Observational evidence from Southern California. *Nature Communications*, *12*(1) *https://doi.org/10.1038/s41467-021-21708-0*
26. Alexeeff, S. E., Deosaransingh, K., Van Den Eeden, S., Schwartz, J., Liao, N. S., & Sidney, S. (2023) Association of long-term exposure to particulate air pollution with cardiovascular events in California. *JAMA Network Open*, *6*(2) *https://doi.org/10.1001/jamanetworkopen.2023.0561*
27. Teresa Feo. (2023, September) *The Human Health Benefits of Improving Forest Health in California: Investigating the Links Between Forest Management, Wildfire Smoke, and the Health Sector*. California Council on Science and Technology and Blue Forest. Sacramento, CA. *https://ccst.us/reports/ the-human-health-benefits-of-improving-forest-health-in-california/*
28. Black, C., Tesfaigzi, Y., Bassein, J. A., & Miller, L. A. (2017) Wildfire smoke exposure and human health: Significant gaps in research for a growing public health issue. *Environmental Toxicology and Pharmacology*, *55*, 186–195. *https://doi.org/10.1016/j.etap.2017.08.022*
29. Bay Area Air Quality Management District. (2023, June) *2023 Annual Air Monitoring Network Plan. https://www.baaqmd.gov/~/media/files/technical-services/2023_network_plan-pdf.pdf?rev=8de9f6f74a2143a994734a3a870bd999&sc_lang=en*
30. PurpleAir. (2023, September 13) *What is the difference between CF=1, ATM, and alt?*. PurpleAir Community. *https://community.purpleair.com/t/what-is-the-difference-between-cf-1-atm-and-alt/6442*
31. Barkjohn, K. K., Holder, A. L., Frederick, S. G., & Clements, A. L. (2022) Correction and accuracy of PurpleAir PM2.5 measurements for extreme wildfire smoke. *Sensors*, *22*(24), 9669. *https://doi.org/10.3390/s22249669*
32. Faloona, Ian C. Sen Chiao, Arthur J. Eiserloh, Raul J. Alvarez II, Guillaume Kirgis, Andrew O. Langford, Christoph J. Senff, Dani Caputi, Arthur Hu, Laura T. Iraci, Emma L. Yates, Josette E. Marrero, Ju-Mee Ryoo, Stephen Conley, Saffet Tanrikulu, Jin Xu, and Toshihiro Kuwayama. (2020) The California Baseline Ozone Transport Study (CABOTS) *Bulletin American Meteorological Society*. April 2020. *https://doi.org/10.1175/BAMS-D-18-0302.1*
33. Delp, William W. and Brett C. Singer. (2020) Wildfire Smoke Adjustment Factors for Low-Cost and Professional PM2.5 Monitors with Optical Sensors. *Sensors* 2020, 20, 3683; doi:10.3390/s20133683
34. LRAPA. (2018) *LRAPA PurpleAir Monitor Correction Factor History*. LRAPA; Springfield, OR, USA
35. Johnson, K., A. Holder, S. Frederick, and A. Clements. (2020) PurpleAir PM2.5 U.S. Correction and Performance During Smoke Events 4/2020. International Smoke Symposium, Raleigh, NC, April 20-24, 2020. *https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=540979&Lab=CEMM*
36. Holder, A. L., Mebust, A. K., Maghran, L. A., McGown, M. R., Stewart, K. E., Vallano, D. M., Elleman, R. A., & Baker, K. R. (2020) Field evaluation of low-cost particulate matter sensors for measuring wildfire smoke. *Sensors*, *20*(17), 4796. *https://doi.org/10.3390/s20174796*

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PRESS SUMMARY

In the summer and fall of 2018 and 2020, major wildfires in Northern California impacted the San Francisco Bay Area. This study was designed to analyze the increase in health effects caused by wildfire smoke using available hospital data at the community level in the Tri-Valley area of the East Bay Area. However, since only monthly hospital data were available publicly from California databases, the relationships could only be implied. Daily hospitalization data are required to quantify their relationship by regression analysis. This study revealed that low-cost PurpleAir sensors likely gave more accurate concentrations during typical air quality but likely tended to overestimate respirable particle air concentrations when wildfire plumes were present.

Disconnected and Online: Privileged Lives of the Transnational Migrants in Mexico City

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ABSTRACT
As global mobility surges, Mexico City has emerged as a favored destination for remote-working professionals due to its unique fusion of cultural allure and economic convenience. This paper explores the interplay between macroeconomic trends and quests for self-actualization among lifestyle migrants, informed by interviews and other fieldwork conducted in Mexico City in early 2023. It unravels the complex interplay of factors shaping attitudes, behaviors, and collective identity among these lifestyle migrants and how their conscious embeddedness dissolves as geographic arbitrage imbues them with new privileges.

KEYWORDS
Digital Nomads; Lifestyle Migrants; Transnational Migration; Mexico City; Socio-Spatial Exclusion; Gentrification; Privilege; Embeddedness

INTRODUCTION

A roster of internet cafés keeps life interesting for David, a thirty-something-year-old from Los Angeles who relocated to Mexico City in mid-2020 at the height of the pandemic. Today, he's at Blend Station in Condesa, with plans to visit a different store of the same chain in Roma Norte in a few days. English menus detail the diverse beverage selection, from various milk types to specialty drinks. The ambient hum of gentle lo-fi beats sets the backdrop, accompanied by the murmur of English conversations rising above the rhythmic clicks of laptops tethered to wall outlets. Baristas, familiar with interacting with foreigners, effortlessly switch to English after a warm "hola" to take orders. David will work here for most of the day before heading to the gym, potentially stopping by Walmart for a quick grocery run. Later, he might meet up with some *"expat buddies"* at a nearby bar.

David is part of the 1.6 million US citizens currently residing in Mexico—a number that has surged in recent years, most notably a 69.9 percent increase in 2022 from 2019.[1] Amidst the rising waves of global mobility, Mexico City has become a sought-after destination for remote-working professionals in their twenties and thirties. Lifestyle migration, as defined by prominent migration scholars Benson and O'Reilly, is the movement of relatively affluent individuals to new destinations in pursuit of a better way of life.[2] Attracted by the city's moderate climate, culinary delights, aesthetic charm, and vibrant culture, coupled with favorable tax policies and proximity to the United States, these white-collar workers are seizing the opportunity to explore new horizons while maintaining their foreign income. Despite the acclaim for the ease of acclimation to a city catering to lifestyles reminiscent of their home countries, concerns are mounting over changes to the city's fabric. Among locals, material impacts of the heating housing market dominate concerns. Housing costs in Mexico City have surged over the past decade, with national house prices rising nearly 12 percent over 2022-2023—the largest annual increase on record, according to the Federal Mortgage Society—while the average sales price of a new home in the United States dropped slightly. Mexico City claims the title of the country's most expensive housing market, with the average apartment price hovering around US$202,000, which is $85,000 above the national average. Upscale districts like Condesa and Polanco, prized for architecture, culture, and culinary scenes, boast some of the city's highest prices, ranging from US$34.37 to US$92.90 per square meter. Last year, the average apartment price in these neighborhoods was around US$600,000, with luxury villas ranging from US$2 million to US$4 million. In Roma Norte, the average residential property price per square meter has surged from $1,500 USD in 2010 to $3,500 in 2023. This surge has made it challenging for many long-time residents to afford to live there, leading to the closure of small businesses due to rising rent, especially in Condesa, Roma Norte, and historic districts. Meanwhile, a 2021 survey of Mexico City residents revealed that 55 percent faced challenges meeting rent or mortgage payments.[3] Almost a third relocated during the pandemic, with 60 percent citing affordability issues as the primary reason. A separate 2020 study highlighted 'alarmingly high' vacancy rates in newly constructed developments, suggesting central housing unit availability was not the primary issue, but rather unaffordability.[4] Meanwhile, city services and commerce are evolving in response to the newcomers. The field of urban geography acknowledges

these trends, but grapples with applying the term 'gentrification' to non-Western contexts.[5] [6] Mexico City, with its proximity and popularity among foreign nationals, demands unique consideration and urgency.

LITERATURE REVIEW

The surge of skilled individuals moving across international borders has sparked significant interest in recent years since the start of the pandemic, which inspired quests for self-actualization and lifestyle change, largely among privileged classes of the Global North. King and Ruiz-Gelices have observed how mobility has been perceived as a vehicle to construct a personal life-course especially evident among young, educated people.[5] As anthropology scholar Hoey puts it, "the choice made of where to live is consciously, intentionally also one about how to live."[6] Ehn argues that this observation is particularly applicable to the years following the pandemic when the world opened up which prompted a desire for change and self-actualization in a time of crisis.[7] In doing so, they may form what psychologist Proshansky termed a place identity, or "those dimensions of self that define the individual's personal identity in relation to the physical environment by means of a complex pattern of conscious and unconscious ideas, feelings, values, goals, preferences, skills, and behavioral tendencies relevant to a specific environment."[8] In the same vein, Savage commented on the ability to attach one's "own biography to their chosen residential location."[9] O'Reilly and Benson have studied this phenomena extensively, from French lifestyle migrants seeking exotic lifestyles in Marrakech, to older Americans moving to Mexico, Costa Rica, and Panama, people from all walks of life now view later life as an opportunity for a fresh start and new adventures in stimulating environments.[2] Accordingly, 'life planning and daily activity' becomes an opportunity for 'self-actualization.'[10] Though they convey various degrees of self-awareness and moral indifference, which Kaddar considers and categorizes,[11] they are unable to escape the "tourist gaze"[12] that Urry assigns to travelers who view foreign places through a lens shaped by their expectations, desires, and cultural background.

Critics like Elliot have scrutinized the individualization thesis, contending that it heavily relies on a rational choice framework while overlooking the emotional and aesthetic impacts propagated by mass media, popular culture, and personal experiences.[13] It also plays down how gender, ethnicity, social class, age and national differences still shape choices and outcomes, which has been studied extensively by Mythen.[14] Finally, it fails to recognize how macroeconomic factors are woven into these lifestyle changes , such as the opportunities spurred by globalization, including the rise of services and the knowledge economy, which Sassen and Castells explore in their exploration of cities and global networks.[15] [16] Neo-liberal governments have gone so far as to reduce barriers to skilled labor mobility by simplifying bureaucratic procedures and immigration laws rather than risk losing foreign investment and skills. Some scholars balance these two sides. Economic sociologists such as Pikettty have long promoted this view of embeddedness in global macroeconomic systems.[17] In migration research, Ong advocates for a balance between the cultural rationale behind migration with individual agency and motivation for capital accumulation.[18] Similarly, Hayes and Zaban point out that perceived motivation in search of a better quality of life often masked desire for geographic arbitrage and economic power in a foreign market.[19]

When considering the emergent lifestyles taken up by these migrants, an important study to consider was conducted on US migrants in Ecuador, in which Hayes considers the socio-spatial exclusion and altered social fabrics that he terms 'gringolandia.'[20] A similar pattern was found in Nicaragua by Rodgers who described 'network-type enclaves' that were formalized by an exclusive fortified network for urban elites, based on the privatization of security and construction of high-speeds roads.[21] In Mexico City, the reputation of being 'nomad friendly' has created a multiplier effect, often intensified by commercial revitalization and urban regeneration programs identified by Delgadillo.[22] Scholars across the board have identified the contribution of foreign workers to rising housing costs and the displacement of residents, resembling typical gentrification patterns seen in the Global North. Derived from Anglo-Saxon theoretical foundations, the term "transnational gentrification" gained renewed relevance amid pandemic-induced international migration patterns.[23] However, its applicability outside the West has been extensively debated due to the complex structural inequalities and power dynamics shaping urban redevelopment in the Global South.

The discussion now explores the perceptions and experiences of these lifestyle migrants in early 2023. First, I argue that though disguised in appeals to lifestyle preferences, economic geographic arbitrage was central in deciding to migrate, although the desire to travel and self-discover was also significant. Secondly, the paper explores their experiences in Mexico City. Upon settlement, they tended to congregate in similar areas of the city and limit interactions to fellow migrants where their lack of Spanish was not a constraining factor, and they could build collective knowledge about taxation and immigration policies that facilitate this lifestyle. While macro-economic factors were front of mind when deciding to move, the desire for self-actualization became more significant and overrode conscious embeddedness in favor of quests for self-actualization and geographic arbitrage.

METHODS AND PROCEDURES

Overview

After obtaining approval from the Institutional Review Board for human research, I conducted 23 semi-structured interviews from January through May of 2023, which were sourced via private chats on WhatsApp and Facebook. I put out two

advertisement blasts on each platform to source interviews and schedule meetings, which took place both in-person and over Zoom. Two were removed due to their upbringing in Mexico. The cohort was majority male (16 vs 6), which was largely attributable to sampling methods and accessibility of interview subjects. Most were millennials or of the Boomer Generation. The most frequent country of origin was the US, along with other predominantly white, industrialized, rich countries like the UK and Australia, but there were also two from India and one from Taiwan. Other than those three, the subjects were majority white (13), and then the remaining five were people of color from the US. The names included in have been invented, although their characters, demographic descriptions and circumstances are consistent with my interview subjects.

Note on Sampling Methods:
This research was conducted in compliance with ethical standards and protocols for research involving human subjects. All participants provided informed consent prior to participating in the study, and their privacy and confidentiality were protected throughout the data collection and analysis process. In order to attract more respondents and humanize my request, I included a public profile picture with my Facebook post. Many of my early respondents were single older white men.[33] Secondary research suggests that this is partly a reflection of the demographics of my subject group, but regardless; my approach to attracting interview candidates affected responses. When meeting and conversing with my subjects, I was careful not to disclose any personal information that could expose me to unnecessary. When I conducted in-person interviews, I ensured that our meetings took place in public, busy locations. In an attempt to diversify my interviews, another group I reached out to was the women-only WhatsApp forum "Hermanas"—a branch of an online community of 400+ women spread across 40 cities that self-describes as a "global feminine movement, contributing to female evolution" that is a "resource for connection and communication with like-minded women, and a collaborate ecosystem of high-quality content." While walking around districts in Mexico City known for their large populations of American expats—Roma Norte, Polanco, Condesa—I approached strangers with American accents and quickly asserted whether they fit the interview profile that I was seeking. My inevitable bias towards 'approachable looking' individuals is laden with my personal bias, which I will attempt to address by including comparative demographic data about my chosen. As a researcher, my background as a privileged individual from the Global North shaped my perspectives and interactions in Mexico City, prompting critical reflection on power dynamics and biases. Historical colonization patterns between Mexico and the US have left lasting cultural and economic disparities, influencing community dynamics and my own positionality as a white researcher and mobile agent. I kept this in mind as I conducted interviews and opted to focus on lifestyle migrants, rather than formalized interviews with locals, to minimize power imbalances and avoid extractive practices.

A Note on Language
For the purpose of this thesis, I will also use the term 'gentrification' to characterize urban effects, recognizing its imperfections but deeming it useful for conveying concepts to an Anglo-American audience. I will also mostly refer to my subject group as 'migrants' unless I am discussing the work of another scholar who uses a specific term. Though there is a resounding preference for elevated classifications labels like 'expat' in my own research, as well as that of scholars Kunz[24] and Cranston,[25] I aim to encompass the diverse categories of remote workers, expats and digital nomads with varying degrees of mobility. Moreover, I want to avoid false elevation or validation above any other type of migrant. The term 'migrant' is politically charged and often used derogatorily. However, the reality is that my subject group is engaged in the same action: moving across international borders. Migration must be considered from a global angle that includes the forms of privileged migration like nomadism. Instead of compartmentalizing these domains, it's valuable to consider the assumptions and inquiries that gain relevance within migration studies when we broaden the scope of "migration" to encompass diverse manifestations of privileged transnationalism.

RESULTS AND DISCUSSION

"What brings you to Mexico City?": The Urge to Migrate
The *"itch to go somewhere"* was a common theme among migrants was a recurring sentiment that was perhaps unsurprising given the timing of these interviews three years after a global pandemic which upended ways of living and kickstarted the remote work boom. This perspective should be immediately noted as a privileged one, which suggests that the pandemic represented an opportunity for change, rather than a period of financial insecurity or danger as it did for the majority of the world. Certainly, numerous interviewees implied that shifts in their existential perspectives fueled a longing for relocation. The translocation of lifestyle migrants was largely shaped by individual choice, rather than structural necessity, though some individuals openly talked about dissatisfaction with their prior socio-economic status in their country of origin. The temporary unique appeal of Mexico City—attributed in part to its lenient travel restrictions, specifically, the country's decision not to close borders to international air travel—became a key factor in their considerations. If this were the sole reason, one might expect this trend to be short-lived. However, the prevalence of responses that referred to pandemic-induced changes in the workplace that facilitated remote work suggest that the pandemic accelerated ongoing long-term institutional changes that facilitated such migrant flows.[15] Even for those who did not reference the pandemic, changes to their personal and professional lives were implied to support or incentivize translocation. Flexible work arrangements demonstrate how mobility is both premised and shaped by ability.

Other factors contributed to Mexico City's unique appeal during this time and otherwise, although of the interviews conducted as part of this study, only three moved before the pandemic. Given the small sample size, this should not be understood as an accurate representation of the transnational migrant population in Mexico City, but it does gesture at a trend. Upon first glance, motivations for moving to Mexico City can be grouped into two camps: economic and 'quality of life narratives.' Alan, a migrant in his mid-twenties working in tech who had been in Mexico City for eight months, gleefully explained the economic pull factors that had motivated his move: *"Mexico is cheap, everything is cheap: rent, food, drink."* Almost without exception, every respondent gave similar reasons, with many like Alan listing it as their primary motivation, echoing Recchi's arguments for the economic motivations. Others made direct comparisons to other major cities, such as New York or San Francisco, wherein they emphasized the appeal of the relatively low cost of living. In their assessments, interviewees included goods (food and alcohol), services (Uber and domestic labor), and rent. One or two referenced the perceived flexibility of foreign tax systems, specifically the US's foreign earned income exclusion that allows qualifying taxpayers to exclude a portion of their foreign earned income from taxable income. The perceived affordability, it was revealed, was often the reason individuals chose to extend their stay indefinitely. Colby, for example, had originally intended to stay in Mexico City for half a year, but was still there almost two years later. He explained his continued presence: *"Because it's so cheap, it's very easy for me to stay."*

Others were less upfront about their fiscal motivations and hastened to clarify that they did not consider economic factors to be the most significant aspect of their choice. Some sought to contradict this previously held assumption with complaints that the city was more expensive than they had originally anticipated; others expressed discontent over the local wages and prices, especially when they were perceived as above market rates. Jim, a financial services professional from Florida, described a *"gringo rent differential,"* and complained that *"it's still fucking expensive relative to what the locals are paying."* Meanwhile, some individuals pushed back on the perception that remote workers were all wealthy, a point that reflects research showing the heterogeneity among skilled migrants from Iredale and Vertovec.[26] [27] Tanya, an African American college student, and Gio, a Philippines expat, emphasized the range of prices in the city, and suggested that they often felt the need to make compromises due to their perceived low socio-economic background in the context of their country of origin. However, when asked to hypothesize why others might move to Mexico City, there was consensus that cost was the most important factor.

Though all interviewees gave at least some mention to economic factors, most quickly moved on to discussing other motivations that can be grouped into the bucket 'quality of life' category. Factors relating to work optimization, such as internet reliability, convenient positioning with respect to the US—specifically common time zones and proximity—were frequently mentioned. Many emphasized the convenience of being able to move quickly between the countries, with the implication that they took frequent back and forth trips for both professional and social purposes.

> *"It's kind of the closest place outside of the US except for Canada, right? Four hours to L.A., three hours and change to Miami, five to New York. So you know, it's so easy for us to hop in and out of the US"* (Colby, March 2023).

Other livability factors included the climate, food, walkability, amenities, and nebulous references to culture, though there was a consistent tension between economic motivations for migration and other socio-cultural factors. Most interviewees emphasized that economic factors were only a small part of their decision to move to Mexico, and that they were secondary to other 'quality of life' factors. However, upon closer examination we see that many of these 'quality of life' motivations are made possible by newly gained economic privilege via geographic arbitrage, which has been commented on by Hayes and Zaban.[19] Based on an analysis of 557 global cities, Mexico City ranks 341st on the cost-of-living index. For migrants moving from countries with a stronger currency, the relative weakness of the Mexican peso, combined with the low-cost of labor power, goods and services in Mexico facilitated an elevated standard of living that would have previously been out of range due to economic status.

Manifestations of this were particularly apparent when it came to leisure activities such as interstate travel, enjoyment of high-quality restaurants, and frequent use of services that facilitate easy passage within the city such as Uber. It can be inferred that many of these benefits were previously inaccessible due to their previously held socio-economic status. Moreover, just as Hoey found that lower costs of living allowed older American adults in Ecuador to live up to certain aging ideals that were culturally important to them, the desirability of more expensive experiential amenities speak to the desire for holistic well-being. balance between personal and professional lives, and in-person experiences following the pandemic.[6] The consistent implication was that such manifestations would not have been possible in their countries of origin due to cost barriers. However, it should be noted that migrants from countries without the extreme exchange rate differential placed noticeably less emphasis on economic factors. Gio from Manila, Philippines expressed uncertainty about whether it would be *"practical financially"* to become a permanent resident in Mexico City because his money was held in Philippine pesos. Migrants from countries with weaker currencies were much less likely to describe Mexico City as entirely low-cost, even if they did not explicitly discuss currency or exchange rates. According to Sanjay from India, Mexico City was *"not too much expensive, not too much cheap—it's in the middle."* Considering this

caveat, therefore, we can conclude that fulfilling Hoey's theory of potentiality and living out *"the Beverly Hills of Mexico"* (Henry, February 2023), so to speak, implies the capital power to do so.

In their assessments of what made Mexico City desirable, many migrants invoked comparisons to other cities. The loci for these comparisons spanned Europe, Asia, Canada and the US, although mentions of these cities were not necessarily grounded in their current reality or personal encounters. Instead, many individuals were drawing comparisons based on their conceptualized notions of these destinations, having never actually visited them, and so may be interpreted as references to the nebulous category of an imagined 'abroad.' The overall vagueness and lack of deep knowledge of the city prior to moving indicated an imagined Mexico City that serves to contrast their experiences in their country of origin. This sentiment is encapsulated in the comment, *"I like to say Mexico City was my favorite city in the Americas that I'd never been to"* (Steve, March 2023). The findings echo Benson's work on imaginaries in lifestyle migration,[28] in which she argues that to demonstrate that migration is revealing of imaginings that often result in a mismatch between expectations and lived experiences. Such was the impression given that these lifestyle migrants' plans were not rooted in research or experience, but rather hyper-individualized fantasy. That said, some implied that their choice of Mexico City over the comparison city was due to a decline in their countries of origin. Individuals from the US specifically recalled the *"political bullshit"* (Jim, February 2023) and described Mexico City as a *"step away."* Often, lifestyle migrants reported being *"inspired"* by friends or online acquaintances who had made the move and being comforted by the endorsement of online communities over amenities such as internet access and security. A few respondents included a romantic partner in their explanations, others listed family. The implication was that the presence of 'in-group' members in Mexico City served as a proxy vetting process by confirming the veracity of Mexico City's reputation for offering an enhanced quality of life. A multiplier effect thus seems likely, given the frequency of responses that mentioned personal contacts that pre-existed their move. Mexico City was compared to Beverly Hills, the West Village (New York), Amsterdam, and Taipei City. Americans often noted traces of European influences in the city, specifically Roma Norte and Condesa, with Eleanor even remarking, *"culturally, it's so European!"* (April 2023). However, the majority of comparisons were contrasts, vague references to 'culture,' and expressions of dissatisfaction with their home region. Individualism was a common critique from those who came from the US, with several stating that they were *"kind of over that environment"* (Alan, February 2023). Factors such as the cost of living, *"political bullshit"* (Jim, February 2023), and other signs of previously attractive areas in the US *"going really downhill."* (David, February 2023) were also mentioned. Encapsulating these sentiments, Tanya stated *"I can't be picky if I want to leave America"* (Tanya, April 2023).

These negative characterizations could be seen as a form of escapism, not exclusive to Mexico City as a destination, and diminishing of arguments that its cultural characteristics presented significant pulls to these lifestyle migrants. However, dismissing references to 'culture' would be overly simplistic and misleading. While there are undoubtedly economic factors which contribute towards this migration trend,[29] they need to be understood within the context of the other considerations which influence individual relocation, such as mentions of culture and lifestyle. Many interviewees explicitly pointed to individualism in the US as motivating their move, suggesting that Mexico City symbolized a departure from this cultural norm, for which there has been growing distaste among young millenials since the pandemic re-invoked the need for collective responsibility. Nevertheless, few provided detailed accounts of any collectivist experiences of lifestyle choices since their arrival, mirroring the lack of perceptible cultural change in the US despite the vocal criticism of individualistic capitalism. While motivations may have been rooted in macro-economic realities and desire for an escape from the hyper-individualism of the US, upon arrival personal fantasies and interests took precedent as they grew in privilege and the returns of mutualism diminished.

The overarching impression that these migrants sought to construct a new life was accompanied by the desire for a new identity, enabled by their decision to move abroad alone and unmarried. Most expressed an expectation that physical relocation would bring about more than just a change in address; rather, they hoped to form a place identity, as Proshansky describes,[8] defined by the activities and lifestyles made newly available to them due to socio-economic opportunities. With diminished importance placed on categories of occupation or nationality, these individuals construct identities through the consumption of leisure goods, services. They strive to live out this imagined identity through their behaviors and the relationships they pursue with others. This desire for an imagined lifestyle was particularly evident among those individuals who mentioned a desire for a romantic partner as one of the reasons for moving. For Kevin, a man in his forties who had lived in Mexico City for just under a year, the change in location unleashed a broad spectrum of new hopes:

> *"Maybe I can find a wife or an apartment. I've been single for a long time now and I haven't really had the time to think about it, but now if the cards are right, money is comfortable, and everything is in my favor, why not?"* (Kevin, April 2023).

The quest for a romantic partner was a common theme in my interviews but cannot be generalized given the limitations of my sampling methodologies. Numerous men suggested a noticeable increase in their appeal to romantic or sexual partners upon relocating to Mexico City compared to their home countries. A few pointed to height as a factor—the average height of a Mexican is 172cm, compared with 175.3cm in the US—, insinuating that standing among Mexican locals made them appear taller

and, consequently, more attractive. Additionally, several men subtly alluded to their newfound relative prosperity and crucially, perceived prosperity as white foreigners among Mexican locals, which elevated their social status, particularly in the realm of dating. Notably, individuals who remarked on their enhanced romantic appeal tended to be of European descent or lighter skin tone. Colorism is deeply rooted in Mexico, manifesting in socioeconomic disparities associated with lighter skin tones.[28] This deeply rooted issue reflects and perpetuates historical legacies and societal attitudes, which create self-fulfilling associations between lighter skin with privilege. The migration of newcomers with lighter skin further reinforces such colorism, which continues to mold social dynamics and shapes opportunities in Mexican society. However, their understanding of this shift often lacked nuance and leaned toward self-aggrandizement, echoing work done on sex tourism that has seen extensive study in Southeast Asia[29], South America[30] and Africa.[31]

Migration for these migrants was more than a change in location. They developed a fantasy of an imagined life that would be afforded by residence in Mexico City where their process of self-actualization could take effect. Nevertheless, the individualistic drive for a higher quality of life is inseparable from the underlying desire for geographic arbitrage, economic leverage within a foreign market, and reaction to macroeconomic trends that lend a more privileged existence in foreign markets.[19]

"Right at Home": Occupying the City

As post-migration routines developed, patterns emerged in the spaces the migrants occupied, the communities they joined, their proficiency in the Spanish language, and their immigration and taxation statuses. These inquiries delve into the behavioral patterns of migrants and offer insight into their integration into the intricate fabric of Mexico City's socio-economic landscape. The narratives that unfolded from these discussions provide insights into the multifaceted impact of these mobile agents on the city, shedding light on the dynamics of their interactions within its diverse societal and economic spheres. Echoing the patterns observed by Hayes and Rogers, each interviewee disclosed residing in four central neighborhoods, Condesa, Polanco, Santa Fe, and Roma Norte, which are among the most affluent neighborhoods in Mexico City. Consequently, the majority of Airbnbs were concentrated in this region. Nearly all participants made remarks about the 'livability' of their chosen neighborhood, either implicitly or explicitly comparing it to their home country. They often highlighted the abundance of parks, restaurants, and shopping districts. Some praised the *"sophistication"* (Eleanor, April 2023) of the residents, noting they were *"different from the rest"* (Colby, March 2023), while others contrasted these areas with what they described as "ghetto areas" (Gio, March 2023). In these neighborhoods, a sense of belonging prevailed, with few expressing feelings of being out of place; instead, many reported feeling *"right at home"* (David, February 2023).

Perceived safety was another common topic. As Low points out, perceptions of safety and crime can differ based on factors such as race, class, and nationality, but that privileged foreigners often gravitate towards affluent neighborhoods or gated communities in urban areas, where they may feel a sense of familiarity and security akin to their home countries.[32] These areas typically offer amenities such as high-quality housing, private security, and access to exclusive facilities. Many migrants expressed concerns about residing in neighborhoods without a significant presence of other foreigners, viewing them as potentially risky areas associated with Mexico's reputation for cartel violence and drug-related issues. According to interview subjects, Condesa and the other listed neighborhoods were *"away from danger."* One interview subject explicitly linked the prevalence of foreigners to safety:

> *"Polanco is a good place, so is Condensa, Colonia, Roma Norte. These are the good places, I've heard. Polanco-Condensa is the safest place because many foreigners are there. I saw there are people at almost every time in the night and police are patrolling. So I think it's a safe place, many foreigners are there"* (Gio, March 2023).

The outcome has been urban fragmentation and segregation, echoing the network-type enclaves in Managua Nicaragua identified by Rodgers.[42] Specifically, the neighborhoods of Roma Norte, Condesa, and Polanco have gained reputations for being predominantly occupied by foreigners. Initiatives such as renovations in public spaces, infrastructure investment, and policy changes aimed at attracting foreign investment have further intensified this effect.[43] Local taco stands and bodegas, once owned by locals, have transformed into yoga studios and cafes in response to shifting demographics and preferences. Even in shared physical spaces, lifestyle migrants in foreign countries actively seek out a community of like-minded individuals to foster a sense of identification.[44] These communities are often formed through online forums and meet-up groups, with online travel communities leading to offline interactions. Building on cue utilization theory, social balance theory, and uncertainty reduction theory, Kunz and Seshadri illustrate how individual reputation, online communication, and perceived similarity among travelers promote in-group socialization, mediated by trust and sympathy.[45] The majority of interviewees described their social circles as primarily composed of migrants *"who were in the same boat."* Shared life experiences and an *"open-minded culture"* formed the essential foundations of these friendships. Despite this commonality, many expressed an appreciation for the diversity within the expat community, welcoming individuals from various high-income, predominantly white countries such as France, the Netherlands, Australia, and the United States. Some individuals expressed a particular affinity for in-group members from ethnic minority backgrounds, and it was clear that the pursuit of community was necessarily an active process that rewarded extraversion.[35] Many

interviewees reported utilizing apps and websites to find meet-up groups for fellow expats. These groups typically convened at bars or restaurants weekly, providing a platform for individuals to exchange life stories and offer recommendations for newcomers to the city. Some groups were more specific, organized around shared interests like hiking, while others carried an element of exclusivity, such as the Emerging Young Entrepreneur Society. Being in a foreign country can inspire in-group bias as estranged individuals gravitate towards familiar language and customs to create a sense of home. However, for some, the inclination to stick with the in-group was motivated by a fear of *"being taken advantage of"* and a perceived vulnerability in an unfamiliar environment. This fear persisted even within online forums of like-minded individuals, as expressed by one individual: *"I have to protect myself… Who would know who the real expats are?"*

While not everyone actively avoided interpersonal relationships with local Mexicans, the implication was that such connections were challenging to establish organically. Interactions were predominantly limited to service providers such as taxi drivers, caterers, and vendors. Language barriers were certainly a factor, yet there appeared to be little interest in bridging this divide. However, there were a few deviations from this trend. Two expats expressed reluctance towards Americans, citing their perceived focus on work and *"venture deals"* (Alan, February 2023). It was suggested that these individuals spent more time with locals, but the negative framing suggested that this preference was driven by aversion to Americans rather than an active interest in the local community. Both expats had arrived with partners from their country of origin, which may have diminished their motivation to seek out familiarity. Another departure from the pattern was observed in the realm of dating, where some migrants shared experiences of romantically pursuing local Mexican women through dating apps. Others who had not encountered such situations expressed interest in the prospect. In many cases, this romantic pursuit served as the sole context for their social engagement with local Mexicans, and some mentioned making friends through these romantic connections. The exclusive focus on romantic relationships with Mexican women implies that migrants perceived themselves as distinctly separate from the local community, and their particular interest may even be interpreted as an offshoot of sex tourism that has been studied in various international contexts.[31-33] Beyond romantic intentions, the majority of interview subjects expressed positive valent views, though perhaps verging on condescending and flattening, characterizing them as *"kind and helpful"* (Lily, May 2023). A common theme was the admiration for their work ethic, succinctly captured by one respondent: *"They're hustlers. They work so hard. Like, they live to work. You can see everyone trying to stay afloat, try and make it work because the government doesn't give them anything"* (Alan, February 2023). Others commended their *"service-oriented"* (Henry, February 2023) culture and hospitality, with Alan noting that it was *"almost to the point of obsequiousness."* He further elaborated on his perception of what he considered an overly reverential attitude towards Americans: money. Alan suggested that the uniquely American tipping culture motivated extravagant displays of service. The transactional interactions between lifestyle migrants and local Mexicans, often limited to service providers and characterized by positive yet utilitarian perspectives, cast an added shadow on the depth of cultural exchange and integration.

Language functions as a pivotal mediator in social interactions, and the majority of my interview subjects acknowledged having only a limited grasp of Spanish, often described as *"poco."* While English has permeated certain areas of Mexico City, it is crucial to recognize that merely 12 percent of the population speaks this language, widely considered a global lingua franca. The prevalence of monolingualism contributes to the perception that these migrants exist within an isolated social bubble. However, interview responses suggest that this is not the sole factor; migrants expressed a proactive motivation to connect with *"like"* individuals (Jim, 2023). When queried about their proficiency in the local language, responses fell into three broad categories: none, some, and fluency. Among those with no Spanish proficiency, respondents implied reliance on translation apps for day-to-day communication— *"Google translate gets me pretty far"* (Colby, March 2023)—sense of isolation from local populations, except for interactions in restaurants and grocery stores where language knowledge would be beneficial. Nevertheless, some mentioned using translation tools when communicating with services like Uber: *"when I need to communicate with the Uber driver, I just use a translator"* (Henry, February 2023). Individuals with basic knowledge recalled college classes but described their proficiency as *"rocky"* (David, February 2023) or *"like a six or seven-year-old"* (Colby, March 2023), asserting that it was nevertheless sufficient. A few noted growing up in a Spanish-speaking household, retaining complete fluency. More interesting, however, was the desire to learn amongst non-fluent speakers. For some there was *"no need"* (Jim, February 2023) because *"[locals] just assume I speak English just because I'm white."* Many expressed their appreciation for this option, describing what they perceived as *"openness"* as a *"confidence boost."* For most, learning Spanish was not a priority, often taking the backseat to more pressing matters like work. Motivation was a limiting factor: *"It depends on my mood. When I first came out, yes, I was going to practice Spanish all the time. And now that I know some Spanish, I'm just like. I'm tired of learning, can we speak English please? If you know someone will speak English then that's fine"* (Eric, April 2023). Yet some did express interest in improving their Spanish and did so, mostly through casual conversations at social places around the city. Others had language apps like Duolingo or even went as far as paying for classes with remote tutors. Still, prioritization remained an issue:

> *"I'm doing Duolingo and teaching myself stuff when I see words that I don't understand and trying to go over stuff for a few hours a day. But I would love to take a class at a university. UNAM has really good Spanish classes that are super expensive, but once I find a job, that's my first priority."* (Tanya, April 2023).

Despite the language barrier and the upheaval of relocating to a new country, many lifestyle migrants discovered that their change in location did not significantly alter their lifestyle and routine. They were able to recreate their previous way of life within their chosen neighborhoods of the city. As Eleanor put it:

> *"My life is still very familiar in a lot of ways. I go to Pilates, I interact with a lot of Americans, we'll get coffee. It feels really normal in a lot of ways"* (Eleanor, April 2023).

Part of this adaptation was facilitated by the accessibility of familiar multinational companies, including Uber, Walmart, and Amazon, which seamlessly transitioned from their countries of origin. Some interview subjects noted a perception that certain prices were higher, likely in response to the increasing spending power in neighborhoods with high numbers of transnational migrants, but they appreciated the convenience of having access to familiar products and modes of commerce:

> *"I just go to the Super Walmart because it's super close and I can tell it's catering to the foreigners"* (Alan, 2023).

The emergence of businesses which *"cater almost exclusively to Western expats"* (Eric, April 2023) was also brought up. Cultural gentrification of retail has been studied in other international contexts, such as shopping centers in Istanbul seeking to cater to international travelers,[36] retail shops in Palma,[37] and the Shenzhen Overseas Chinese Town (OCT) community in China.[38] One example mentioned in interviews was Nurish, a meal-prep service that offers familiar items like Mac n' Cheese. By contrast, local markets presented an unpredictable, potentially uncomfortable scenario, in which non-Spanish speaking migrants felt disadvantaged by their inability to communicate or barter. While some interview subjects proudly discussed their dexterity in these circumstances, others expressed distaste or anxiety about such modes of commerce. The implications of these unifocal social attitudes and the physical separation of social groups in cities are closely linked to social network segregation. Spatial segregation in Mexico City predates the arrival of these migrants; indigenous communities have historically been confined to denser urban spaces, often characterized by higher crime rates and lacking 'healthy' amenities such as large parks. There has been a consistent trend of seeking safety in similarity, extending beyond nationality or life experience to a perceived safety in socio-economic and racial homogeneity. As noted by Giglia, "living in segregated residential spaces in Mexico City is a complex social process that results not only from the fear of crime but also as a way to escape urban disorder and to establish islands of social homogeneity."[39] That said, not all were content with the distribution. Some chose to diplomatically label the tendency to congregate as *"interesting,"* while others expressed negativity: *"They're all going the same fucking places, the same fucking restaurants, the same high-quality bars… It's the same shit"* (Jim, February 2023).

Responses to inquiries about 'challenges' further underscored the divide between the migrants and locals. Encounters with poverty and housing were unavoidably viewed through the lens of the privileged 'tourist gaze,' as conceptualized by sociologist John Urry. The fact that their exposure to hardship was confined to observing others endure it highlights the profound disparity in how they perceive and engage with the city: what one group endures, the other observes. This divide also shapes the identity of Mexico City—a city that promises differential experiences for migrants and locals. These perspectives materialize in spending patterns that favor American multinational corporations like Walmart over local tienditas, and Ubers over traditional taxi services. Airbnbs and acclaimed 'best restaurants' are spatially concentrated in affluent areas like Polanco, Condesa, and Roma Norte. Benson and O'Reilly underscore the profound impact of privileged identities in shaping and being shaped by their environment.[2] Despite this constructed experience, the sense of belonging is not necessarily diminished, as evident in one migrant's affirmation of feeling *"right at home"* (David, February 2023). Such seamless adjustment is distinctive to these migrants, as my interviews revealed that typical barriers like housing and immigration were overcome through passport and economic privilege. Their presence faced no challenges from anxieties or legal authorities, enabling their perception of a welcoming *"nomad paradise"* (Colby, March 2023). This contrasts sharply with the experiences of other migrants who encounter harsh treatment at borders, such as the US-Mexico border, endure overcrowded and unsanitary detention facilities, and struggle to secure employment and housing upon reaching their destination. Drawing on Proshansky's environmental psychology[8] and Savage's concept of 'elective belonging,'[9] we can interpret such comfort as a manifestation of power, and adaptability as a performance—both essential elements in, as Savage puts it, '[attaching] [one's] own biography to their chosen residential location.'"

Not Always a "Nomad Paradise": Logistics & Challenges

As migrants settled and adapted to life in Mexico City, they encountered challenges, which encompassed a spectrum of concerns ranging from environmental issues to bureaucratic complexities related to taxation, property, immigration, and residency. As they navigate their way through a new country, these migrants confront and adapt to the idiosyncrasies and administrative intricacies that significantly shape their experiences. Pollution, discomforting proximity to poverty, immigration statuses, taxation, and property-related decisions emerged from the interviews as prescient themes. Understanding these intricacies can help inform policies and initiatives aimed at enhancing their integration and overall well-being in their new adopted home.

Despite Mexico City's positive reputation and glowing reviews on countless tourist websites, a prevalent grievance among the expat population was the severe pollution. The country has long grappled with poor air quality and while measures have been taken to mitigate pollution, Greenpeace estimates that PM2.5 air pollution contributed to as many as 15,000 premature deaths in Mexico City in 2020. Six interview subjects expressed concerns about the pollution, noting its impact on their daily routines, with one stating, *"the pollution here is to the point where my throat is burning when I'm on a morning run"* (Eric, April 2023). Others mentioned acid rain, emphasizing the vulnerability of newcomers unaware of the risks: *"The locals will get out of the rain because they know the acid rain will destroy their hair, and that if they drink it or it gets in their mouth, it's a problem. But the expats don't really realize the effects of acid rain and the pollution in Mexico City"* (Lily, May 2023). A final comparison was drawn to Vietnam, specifically the presence of Agent Orange, a chemical herbicide and defoliant used by the US military in herbicidal warfare: *"Air, water, air, water, food is a problem. You go to Vietnam and Agent Orange runoff is in all the food, and you're eating it"* (Jim, February 2023). This comparison speaks to the intensity of their concerns and reflects a disconnected understanding of historical and sociopolitical contexts in both countries. Pollution proves to be an inescapable issue, and it is one of the few problems that privilege cannot shield these migrants from. Every resident of Mexico City breathes the same air, sharing the experience in more-or-less equal measure. The same cannot be said for poverty, a theme that surfaced in numerous interviews. Migrants expressed surprise and distaste for the visible poverty in the city, despite their insulation. Adam, an IT technician, remarked, *"I was a little bit taken aback by the poverty on the street."* Yet, in the same breath, Adam conveyed a sense of price discrimination based on his origin: *"For an American paying $2,000 in Mexico City versus $3,500 in New York, it's a steal, but it's still expensive relative to what the locals are paying"* (Adam, February 2023). Similarly, Suzanne, an online content creator, shared her sentiments about the cost of living and the resulting poverty: *"The price of a cocktail here is way more than it was two years ago. The cost of living, the amount of poverty has risen"* (Suzanne, May 2023). While neither poverty was a direct personal concern for Suzanne nor Adam, its peripheral presence was pronounced enough to warrant mention. Their juxtaposed comments about rent and cocktails underscored their alienation from the experiences of others in the city and, perhaps, their limited social conscientiousness toward those of a different social class.

Other perceived challenges revealed a varying degree of self-awareness, particularly within the broader geopolitical context of migration from Mexico into the US. Krysten openly admitted, *"it was a little hard finding an apartment because I don't have any paperwork that lets me be here officially,"* (April, 2023). The tourist visa referenced is the authorization granted to citizens from the US, Canada, and other high-income nations, allowing them to stay in Mexico without a visa for 180 days as a Visitante (visitor). The immigration system is computerized, and no paperwork is required prior to arrival. Still visa runs—leaving the country every few months and returning with a new tourist status—remain a popular method for foreigners to live in Mexico. Alternative avenues include applying for a temporary resident visa, which is valid for up to four years and allows individuals to obtain a driver's license, open a bank account, enroll in the IMSS national healthcare plan, and access medical services through the free INSABI healthcare system. For those seeking employment in Mexico, an employer must request a temporary resident visa with a work permit.

The majority of interview subjects were visitors without visas, expressing positivity about the ease of entering and leaving the country. One even described it as a *"nomad paradise"* (Colby, March 2023). Others elaborated on the lifestyle that facilitates such ease: *"I never stay 180 days. Let's say maybe three months, four months...And you'll hear a lot of controversy on that,"* (Eric, April 2023). Most did not have residency, and many believed that applying for it would be unnecessary: *"I don't even have residency here. I don't need to set up bank accounts. I may be buying property, but I don't need any of that,"* (Henry, February 2023). While a few expressed interest in starting the process, Madeline provided an exception as someone who had successfully seen the residency process through:

> *"Yes, so I do have residency. I will say it probably took me two visits, just because there's a backlog from Covid and everything… I do think that it's really important for expats who plan on making Mexico home to become legal within the city. It is giving us so much. And just to be cognizant of the fact that for many people, the roles are reversed. They're not able to travel as really to the states or Europe or whatever as we are. I just think it's the right thing to do, to be legal within the country as well. Other people don't have the luxury. I have friends who are from Mexico that have been waiting for their visa appointment to go to the States just for vacation for a year now. So it's just another way to recognize our privilege and be respectful for the community that we're entering." (Madeline, 2023).*

This level of self-awareness proved to be uncommon among the migrants. Even when they did not intentionally attempt to exploit loopholes and privilege, their ignorance about the process indicated an ability to navigate a complex immigration system without the anxiety of being held accountable for a misstep or oversight. This privileged confusion also extended to taxation. The vast majority of interview subjects were not taxed in Mexico due to their employment overseas. Most expressed some degree of confusion about their tax status: *"I pay taxes in the US, and I think I'm still considered a tourist here. I still need to go back to the States from time to time. That's my understanding"* (Jim, February 2023). However, Eleanor reported paying taxes in Mexico and emphasized the *"privilege we have to be here, especially coming from first and second world countries that have stronger passports."* Others took the opposite

approach, expressing neither confusion nor a sense of obligation to contribute but instead exhibited confidence in their eligibility for certain tax loopholes between countries.

> *"Are you familiar with FEIE or foreign earned income exclusion? That's one of the huge advantages to being here. I'm essentially paid to be out of the country. If I'm going to spend 330 days outside of the United States, then I can basically save $20,000 on the first $107,000 of income. I pay some tax, but I'm not paying huge amounts. I do business in the US. Overall that was the reason why we chose Mexico. And the way that the taxation works is if the physical location of your entity or your business is in the United States, you pay tax in the US. That's how Mexico looks at it. The US looks at it with the FEI. You pay tax on where you're physically located, or at least you can leverage those exemptions based on your physical presence."* (Jim, February 2023).

The issue of wealthy individuals exploiting tax systems by maneuvering between borders has garnered attention in academic literature. Scholars have documented various strategies employed by affluent taxpayers to minimize their tax liabilities, including the use of legal loopholes such as the foreign earned income exclusion (FEIE). High-net-worth individuals have been shown to strategically structure their income to qualify for the FEIE, allowing them to exclude a portion of their foreign earnings from U.S. taxation.[40] Top earners have been found to be disproportionately likely to engage in tax avoidance strategies, exacerbating wealth disparities within and across countries.

The concerns raised by these migrants underscore their privileged position, predominantly manifested in logistical inconveniences. While taxation and immigration presented personal challenges for some, they enjoyed the luxury of not being overly burdened by such concerns. Mobility was understood as a right, not a privilege, and their freedom of movement was part and parcel of their quest for self-actualization as a 'global citizen.' Yet while their individual freedoms were inextricably linked to the macro-geopolitical privilege stamped on their passports, their considerations fell short of grasping the bigger picture.

Emerging Identities

Interview subjects had varying degrees of awareness about their impact on the city. For a select few seeking to be *"very intentional as expats"* (Madeline, April 2023), positionality was front of mind:

> "*Regardless of the place of origin, I think it's really important with all the impacts that we can have on a place… And that goes beyond just learning Spanish. It's about trying to pay local prices for housing, being cognizant of your presence, being open to learning new customs, and really trying to acclimate versus just kind of using the city as your playground. Gentrification is a global issue. It's not gonna stop. But I do think we can be intentional about how we spend our time and our money and how we foster community within the city.*" (Madeline, April 2023).

Others held a contrasting view, contending that their presence in Mexico City was a positive contribution to the local economy. As Jim emphasized, *"I do nothing but infuse dollars and contribute to this economy."* This disagreement often unfolded in online group discussions, sparking debates about the social responsibilities of digital nomads. When it came to the issue of gentrification, opinions were divided. Some were firm in their belief that the city has "*changed for the better"* since its earlier status as *"truly kind of third world"* (Henry, February 2023). Frequently, these migrants cited improvements in safety and the increased availability of convenient services as reasons supporting their perspective:

> *"Before Uber, it was sketchy to call a taxi off the street cause you would get kidnapped and they would go to the ATM and would rob you of all your money. But since Uber, it has made the whole city a lot safer"* (David, February 2023).

However, these positive sentiments were tempered by concerns about the ongoing transformations evident in the city. Even David conceded that the city had *"become a lot more expensive for locals."* Many expressed apprehensions about continuously rising prices: *"the influx of expats has increased substantially, and you see that mainly in the real estate market. It's crazy—the demand for apartments right now"* (Alan, February 2023). Others went a step further by recognizing the broader cultural shift that entailed negative consequences for local populations:

> *"In restaurant settings, people don't even attempt to speak Spanish. It's straight away English. They automatically assume that everyone speaks English… You see baristas start to speak English automatically just because that's kind of what they're used to. Now, the price of a cocktail here is way more than it was two years ago. The price of living, the amount of poverty has risen… people can't afford to live where they have lived their whole life, which is the epitome of gentrification,"* (Suzanne, May 2023).

Suzanne wExperiences of gentrification were influenced by positionality, encompassing both past and present perspectives. Tanya, a Black college student, discussed the misalignment of her understanding of 'gentrification,' typically associated with the influx of white individuals into communities of color.

> "*Even my existence here as a Black woman, that's gentrification. It's hard to come to terms with it because I think people lack that self-reflection. I was trying to shield myself or make an excuse for it. To an extent it is a little bit different, but it's not my mere existence here as an American, but benefiting from a cheaper economy it's the same thing. It's the same.*" (Tanya, April 2023).

Tanya's side-gig was in the world of online influencers, where she posted romanticized images and videos promoting Mexico City as an ideal destination for remote living and work. Her social media feed depicted a vibrant rotation of cafes, parks, and clubs in the Polanco-Condesa areas, typically in the company of her expat community. The exuberant lifestyle she advocated surpassed even Tanya's own, but even further removed from the everyday reality experienced by the majority of the city's residents. Theoretical awareness appeared disconnected from her daily life choices. According to Kaddar's schema that analyzes gentrifiers by their sense of efficacy and interest in remedying the negative outcomes of gentrification,[11] most migrants fell into the 'Shrugger' category; morally indifferent with a feeling that even if they tried, they could do little to help the situation. Tanya's following statement, *"That's really sad, but it's hard... it's one of these global economic situations"* encapsulates this attitude. There were two noticeable 'Agonizers' who expressed a high degree of moral discomfort at the perceived outcomes of gentrification, but still scored low in efficacy or perceived ability to remedy the situation. There was a distinct demographic distinction between these groups. Those who saw their presence as morally neutral or even a boost for the economy were predominantly white men like Jim and Colby. Meanwhile, the two 'Agonizers' were both women of color who offered an in-depth discussion of her feelings over positionality in Mexico City. Personal experience, education, social consciousness, allyship, and engagement in open dialogues about privilege may have contributed to this greater recognition of unequal power dynamics at play. It also reinforced the importance of consistently needing to revise definitions of gentrification to fit shifting power dynamics in a globalized world. The significance of race and gender identities are contextual; taking on the transnational migrant identity invokes a new privilege that may not have been held as a Black woman in North America. Yet the neighborhood change and involuntary displacement was, in the case of this interview subject, a familiar pattern. Hence, the awareness persisted.

This variation in opinion unfolded within Reddit discussions, specifically under the thread titled *"How do you guys deal with people saying we are colonialists/parasites ruining local communities etc.?"*[41] The predominant responses derided the notion, with certain contributors dismissing the arguments as confined to online forums for *"fat purple-haired liberal white chicks"* and contending that *"people [in Mexico] [are] begging for the same tourism levels pre-Covid."* Some commenters expressed sympathy toward the question, acknowledging issues like rising rents in Mexico City caused by foreigners and responded to the naysayers:

> *" Foreigners have been moving into Mexico City and driving rents significantly higher, causing the locals to be unable to afford their rents anymore. They are moving farther out and in turn causing the rents farther out to be significantly higher. A lot of it has to do with expats living the high life instead of the average local."*

However, the ensuing dialogue revealed defensive responses, exemplified by vitriolic retorts such as, *"I suppose you'd be looking to point the finger at some gringo on his laptop in Starbucks making $40K a year."* While defensiveness is perhaps to be expected, the extent of self-awareness should not be overstated; cognition of positionality is undermined by the distortions of the 'tourist gaze' that undercuts any conception of objectivity.[12] As Tanya's social media page suggests, awareness is not necessarily paired with lived consciousness. Cognizance of macro-economic systems that motivated migration did not continue upon arrival when their positionality shifted from perceived disadvantage to hyper-privilege in a foreign market.

CONCLUSION

"Do yourself a favor and remote work in Mexico City—it is truly magical ✨" – Twitter thread, February 16th, 2021.

The now-deleted tweet from a migrant from Austin, TX is among a litany of recommendations peppering the Internet that extolling Mexico City as an ideal hub for remote work. It became the eye of a brief Twitter storm that reflected the tensions between affluent migrants and Mexican locals. The *"magical"* characterization was of particular annoyance, but it carried an ironic accuracy. Though migrants' motivations for moving were tied up in macro-economic factors, desire for self-actualization took precedence leading up and especially upon arrival when awareness of positionality and embeddedness fell away. Existing scholarship has mainly focused on the impacts of these migrants, alongside some work on their perceptions and motivations. My research delineates migrants' engagement with macro-economic motivations, which in large part incentivizes their location but falls away upon arrival when their positionality transitions from feeling disadvantaged to grappling privilege or failing to do so.

Further exploration is required to understand the nuances of how these viewpoints, attitudes, and aspirations manifest, shaping their new environment. To achieve this, a more in-depth investigation is necessary. Firstly, a thorough analysis of migrants' distinct spending patterns is crucial, considering whether their familiarity with multinational corporations influences their preference for entities like 7-Eleven Inc., Uber Technologies, Inc., and Walmart Inc. Understanding these spending behaviors would illuminate where the economic capital of the expatriate community in Mexico concentrates and its potential impact on local

commerce. Secondly, exploring the divergent experiences between white people and people of color in the context of lifestyle migration warrants further investigation. Particularly noteworthy is the scarcity of scholarly attention devoted to non-white lifestyle migrants. Understanding how race intersects with migration decision-making is crucial, exemplified by initiatives like Ghana's efforts to attract African American "digital nomads," where motivations for relocation intertwine with perceptions of US racism and African identity. Whether similar dynamics manifest among lifestyle migrants in Mexico City remains unexplored, presenting an opportunity for future studies to delve into these complex and understudied intersections. Thirdly, my interviews uncovered an unforeseen attitude among male migrants towards local women, suggesting potential negative repercussions and the emergence of new avenues for exploitation. Addressing this issue requires further comprehensive research to comprehend its dynamics and implement protective measures through stringent policies, education initiatives, and the empowerment of Mexican women. Lastly, investigating how the increasing awareness of transnational gentrification manifests in self-regulated or government-regulated behavior is essential for understanding its implications and devising appropriate policy responses. These areas present exciting opportunities for future research, allowing for a deeper understanding of the dynamics of transnationalism and its broader societal ramifications.

In the ever-evolving landscape of mobility and globalization, the case study of digital nomadism in Mexico City unveils unique insights into the intersection of transnational gentrification, geographic arbitrage, and lifestyle choices amongst individuals and groups. While digital nomadism promises liberation from traditional workplace constraints, it also reflects and perpetuates existing power structures of white supremacy, misogyny, and settler colonialism. Mexico City was, for many migrants, a backdrop for self-actualization. We must balance the macro-socio-economic trends that drove migration with individual motivations to understand why it has become a hub for these lifestyle migrants and how their attitudes manifest upon settlement.

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REFERENCES

1. Secretaría de Hacienda y Crédito Público (SHCP). (2023) Criterios generales de política económica para la elaboración de las leyes de ingresos de la federación y de ingresos sobre hidrocarburos del ejercicio fiscal de 2024. Retrieved from *https://www.gob.mx/shf/documentos/90727*
2. Benson, M. and O'Reilly, K., 2009, Migration and the search for a better way of life: a critical exploration of lifestyle migration. *Sociological Review*, 57(4), 608-625. *https://doi.org/10.1111/j.1467-954X.2009.01864*
3. Azuela de la Cueva, A & Silvia Emanuelli, M & Silvia Emanuelli, S. (2021) "Sondeo sobre la situación de las personas que residían en viviendas rentadas, hipotecadas o prestadas en la cdmx antes y durante la pandemia." CDMX. *https://www.iis.unam.mx/wp-content/uploads/2022/01/Reporte-Viviendas-Rentadas-Rev2-131221.pdf*
4. Reyes, A. (2021) "Mexico's housing crisis: vacancy, limited access & Deaf policy responses." *International Journal of Urban Sciences*, 25:sup1, 167-194. *https://doi.org/10.1080/12265934.2020.1776145*
5. King, R. and Ruiz-Gelices, E. (2003) 'International student migration and the European "year abroad": effects on European identity and subsequent migration behaviour', *International Journal of Population Geography*, 9(3): 229 52. *https://doi.org/10.1002/ijpg.280*
6. Hoey, B. A. (2005) From pi to pie: Moral narratives of noneconomic migration and starting over in the postindustrial Midwest. Journal of Contemporary Ethnography, 34(5), 586-624. *https://doi.org/10.1177/0891241605279016*
7. Ehn, K., Jorge, A., & Marques-Pita, M. (2022) Digital Nomads and the Covid-19 Pandemic: Narratives About Relocation in a Time of Lockdowns and Reduced Mobility. *Social Media + Society*, 8(1) *https://doi.org/10.1177/20563051221084958*
8. Proshansky, H.M., et al. "Place-identity: Physical World Socialization of the Self." *Journal of Environmental Psychology*, vol. 3, no. 1, Mar. 1983, pp. 57–83. *https://doi.org/10.1016/s0272-4944(83)80021-8.*
9. Savage, M., Bagnall, G., & Longhurst, B. (2005). Globalization and belonging. SAGE Publications Ltd, *https://doi.org/10.4135/9781446216880*
10. Giddens, A. (1991) Modernity and Self-Identity: Self and Society in the Late Modern Age. Cambridge: Polity.
11. Kaddar, M. (2020) Gentrifiers and attitudes towards agency: A new typology. Evidence from Tel Aviv-Jaffa, Israel. *Urban Studie*s, 57(6), 1243–1259. *https://doi.org/10.1177/0042098020904252*

12. Urry, J. (1990) The tourist gaze: Leisure and travel in contemporary societies. London: Sage.
13. Elliot, A. (2002) 'Beck's sociology of risk: a critical assessment', *Sociology*, 36(2): 293315. *https://doi.org/10.1177/003803850203600200*
14. Mythen, G. (2005) 'Employment, individualization and insecurity: rethinking the risk society perspective', *The Sociological Review*, 53(1): 12949.
15. Sassen, S. (2000) Cities in a World Economy. *Thousand Oaks*, Ca: Sage. *https://doi.org/10.4135/9781071872710*
16. Castells, M. (1996) The Rise of the Network Society. Oxford: Blackwell. *https://doi.org/10.30935/cedtech/6177*
17. Piketty, T., & Goldhammer, A. (2015) The Economics of Inequality. Harvard University Press,. *https://doi.org/10.4159/9780674915565*
18. Ong, A. (1999) Flexible citizenship : the cultural logics of transnationality. Duke University Press. *https://doi.org/10.1017/S0964028202230086*
19. Hayes, M., & Zaban, H. (2020) Transnational gentrification: The crossroads of transnational mobility and urban research. *Urban Studie*s, 57(15), 3009–3024. *https://doi.org/10.1177/00420980209452*
20. Hayes, Matthew. Gringolandia. 2018, *https://doi.org/10.5749/j.ctv6q52rv*.
21. Rodgers, D., 2004. 'Disembedding' the city: crime, insecurity, and spatial organization in Managua, Nicaragua. *Environment and Urbanization,* 16 (2), 113–123. *https://doi.org/10.1177/095624780401600202*
22. Delgadillo, V. (2016) "Selective modernization of Mexico City and its historic center. Gentrification without displacement?" *Urban Geography*, 37(8), 1154-1174. *https://doi.org/10.1080/02723638.2015.1096114*
23. Díaz-Parra, I. (2021) Generating a critical dialogue on gentrification in Latin America. *Progress in Human Geography*, 45(3), 472-488. *https://doi.org/10.1177/0309132520926572*
24. Kunz, S. (2019). Expatriate, migrant? The social life of migration categories and the polyvalent mobility of race. *Journal of Ethnic and Migration Studies. https://doi.org/10.1080/1369183X.2019.1584525*
25. Cranston, Sophie. (2017) Expatriate as a 'Good' Migrant: Thinking Through Skilled International Migrant Categories. *Population, Space and Place.* 23. 10.1002/psp.2058. *https://doi.org/10.1002/psp.2058*
26. Iredale, R. (2001) 'The migration of professionals: theories and typologies', *International Migration*, 39(5): 7 26. *https://doi.org/10.1111/1468-2435.00169*
27. Vertovec, S. (2002) Transnational Networks and Skilled Labour Migration. *Transnational Communities, Working Paper 02–02.* Oxford: University of Oxford
28. Benson, M. (2012) How Culturally Significant Imaginings are Translated into Lifestyle Migration. *Journal of Ethnic and Migration Studies*, 38(10), 1681–1696. *https://doi.org/10.1080/1369183X.2012.711067*
29. O'Reilly, K. (2000) The British on the Costa Del Sol. London: Routledge. *https://doi.org/10.4324/9780203495407*
30. Villarreal, A. (2010) Stratification by Skin Color in Contemporary Mexico. *American Sociological Review*, 75, 652 - 678. *https://doi.org/10.1177/0003122410378232.*
31. Leheny, David. "A Political Economy of Asian Sex Tourism." *Annals of Tourism Research*, vol. 22, no. 2, Jan. 1995, pp. 367–84. *https://doi.org/10.1016/0160-7383(94)00082-4.*
32. Lu, T.S., Holmes, A., Noone, C. et al. Sun, sea and sex: a review of the sex tourism literature. *Trop Dis Travel Med Vaccines* 6, 24 (2020) *https://doi.org/10.1186/s40794-020-00124-0*
33. Kachipande, Sitinga. "Sun, Sand, Sex, and Safari: The Interplay of Sex Tourism and Global Inequalities in Africa's Tourism Industry." *Journal of Global South Studies*, vol. 40, no. 1, Mar. 2023, pp. 1–37. *https://doi.org/10.1353/gss.2023.0007.*
34. Low, Setha M. "The Edge and the Center: Gated Communities and the Discourse of Urban Fear." *American Anthropologist*, vol. 103, no. 1, Mar. 2001, pp. 45–58. *https://doi.org/10.1525/aa.2001.103.1.45.*
35. Kennedy, P. (2004) "Making global society: friendship networks among transnational professionals in the building design industry", *Global Networks*, 4(2): 15780. *https://doi.org/10.1111/j.1471-0374.2004.00085*
36. Egresi, I., Arslan, S. (2016) Shopping and Tourism in Turkey: The Perfect Combination. In: Egresi, I. (eds) Alternative Tourism in Turkey. *GeoJournal Library*, vol 121. Springer, Cham. *https://doi.org/10.1007/978-3-319-47537-0_13*
37. Blázquez-Salom, M., Blanco-Romero, A., Carbonell, J., & Murray, I. (2019) Tourist gentrification of retail shops in Palma (Majorca). Overtourism: excesses, discontents and measures in travel and tourism. *https://doi.org/10.1079/9781786399823.0039.*
38. Liang, Z., & Bao, J. (2015) Tourism gentrification in Shenzhen, China: causes and socio-spatial consequences. *Tourism Geographies*, 17, 461 - 481. *https://doi.org/10.1080/14616688.2014.1000954.*
39. Giglia, Angela. "Gated Communities in Mexico City." *Home Cultures*, vol. 5, no. 1, Mar. 2008, pp. 65–84. *https://doi.org/10.2752/174063108x287355.*
40. Altshuler, Rosanne & Grubert, Harry. (2003) Repatriation Taxes, Repatriation Strategies and Multinational Financial Policy. *Journal of Public Economics*. 87 (1): 73–107. *https://doi.org/https://doi.org/10.1016/S0047-2727(01)00173-6.*
41. Reddit. "How Do You Guys Deal With People Saying We Are Colonialists/Parasites Ruining Local Communities Etc?" Reddit, Sept. 2023, *www.reddit.com/r/digitalnomad/comments/16qwd3f/how_do_you_guys_deal_with_people_saying_we_are* (accessed December, 2023).

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PRESS SUMMARY:

Amid ever-increasing global mobility for privileged classes, Mexico City has become a popular destination for remote-working professionals. Based on 23 interviews conducted in early 2023, this paper examines the interaction between macroeconomic trends and the pursuit of self-fulfillment among lifestyle migrants. It explores the complex factors influencing their attitudes, behaviors, and collective identity and how their deliberate integration into the local environment diminishes as geographic arbitrage brings new advantages.

Undergraduate Students' Confidence in Scientific Activity and Support Systems Based on Diversity in an Environmental Science Course

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ABSTRACT
Undergraduate student support systems and individual confidence in science courses have been linked to better academic performance among college students. As the topics of diversity and inclusion continue to draw the attention of the collegiate, the problem of equity surrounding supportive learning environments for all races in higher education comes into focus. This paper adds to the literature by highlighting the importance of adequate support for students in collegiate settings.

Disparities in student support and confidence with scientific activities among students of color (SOC) and white students in an undergraduate environmental science course had been evaluated. Students (n = 235) were asked to complete a Qualtrics survey containing questions focused on evaluating support from parents, siblings, close relatives, friends, peers, classmates, and professors and confidence regarding self-efficacy in learning and doing scientific activities. The perceived support and confidence in scientific activities in white students and SOC were measured using an independent T-test. The findings demonstrated that white students may have had access to stronger support systems and had higher perceived confidence levels in completing scientific activities based on survey responses. On average, white students had greater perceived support and more confidence. As a result, higher dropout rates, lower performance overall, and alienation of these students in higher education environments could occur. If this trend continues, racial discrepancies suggest that students of color need stronger support networks related to scientific activities in higher education settings.

KEYWORDS
Student Support; Student Scientific Confidence; STEM Confidence; Students of Color; Academic Support; Undergraduate Student; Family Support; Student Peers

INTRODUCTION

As the population of the United States of America continues to increase in racial diversity, opportunities to examine inequities within institutions pertaining to diverse groups will grow as well. It is well known that generational wealth and legacies of groups holding power in the country have led to disproportionate wealth and educational gaps.[1] According to the 2019 Survey of Consumer Finances, even though white citizens made up about 68.1% of the country's population, they held 86.8% of the country's overall wealth.[2] These racial disparities often begin at the educational level where a larger family income can be associated with children receiving better quality primary and secondary school education.[1] This support from family early on to curate a safe and healthy primary and secondary school education is extremely influential on a student's desire, confidence, and ability to achieve success in higher education.[3] The motivations for students to explore their individual creativity in educational fields and allow themselves to prosper in university settings depends on crucial factors such as support and mentoring.[4] In this study students enrolled in an undergraduate environmental science course were surveyed to gather data on their individual perceived confidence in science-related activities and perceived support systems available to them. The survey results were evaluated with respect to student's racial backgrounds.

Previously, support of students of color (SOC) in higher education and confidence had been studied separately within literature. A study by Fuse & Bergen[5] found that support for underrepresented groups in a professional science field differed based on racial background. The study highlighted the need for better emotional, financial, and alumni role model support and discussed how this impacted support in academic outcomes and graduate admissions. However, there is a lack of papers addressing the

relationship between both support and confidence variables on students' of color ability to succeed, in contrast to their white counterparts. This study seeks to examine both items and observe any potential differences between the two based on race.

In this study we used Phillips et al.[6] for the definitions of scientific activity confidence and support, which examine and explore the framework for articulating and measuring learning outcomes in the scientific field. This study defines self-efficacy in the scientific field as the "extent to which a learner has confidence in his or her ability to participate in a science or environmental activity".[6] The questions modeled around the student's self-efficacy and identity were used in this study to give insight on a student's perceived confidence surrounding scientific activities. Support in this study is defined based on London et al.,[7] which describes the influences that perceived identity compatibility and social support have on women in nontraditional fields during their transition into college. The study defines social support to include "emotional concern or comfort, affirmation, instrumental or tangible assistance, and the provision of information" from close friends, family members, and others around the students.[7]

Support is a broad category that offers students a better chance at success. Familial Support includes many factors like familial structure, familial socioeconomic status, familial level of education, familial involvement in academic preparation, familial emotional connection, and more.[8] These factors all contribute to ways a student can be supported by their families. Social and institutional support is just as important as these factors and contributes to a student's self-esteem, validation, sense of community and direct connections while away from home. [8] Institutional support for students can be seen as an extension of a familial community that will be students "rock and a support to lean on".[4] Some ways in which students can be supported better by family in these settings would be to have families draft an academic success plan for their student, discuss their students futures in the academic world with professors and advisors, take factors of adversity such as the stereotypical hardships that come depending on race into account, help their student identify sources on campus that can help students with additional academic and social issues, and to encourage students to get involved on campus.[8] Institutions can better support students by increasing the diversity of faculty, encouraging the facilitation of diversity conversations on campus, and .Support is a large aspect of a student's path to success and analyzing discrepancies in higher education can bring academia one step closer to closing the gap.

METHODS AND PROCEDURES

A total of 235 students were surveyed in an undergraduate environmental science course at a large land grant university in the southeastern United States. This study was originally conducted with a sample size of 238 students enrolled in an introductory environmental science course. Among these students, three of the responses were dropped due to the students preferring not to answer demographic questions including race, gender, and other categories. This study received exemption status by the North Carolina State University Internal Review Board (NCSU IRB # 14368).

Qualtrics™ was used to develop and implement a survey that included socio-demographic (age, classification, gender identity, race and major) and support questions which were adapted from London et al.[7] Students were asked if their mother, father, siblings, other close relatives, friends, peers, and professors supported them in their major/educational pursuit using a Likert scale (1 being strongly disagree and 7 being strongly agree). This scale rated the perceived support of individuals who were close with the students and would have influenced their journey throughout their academic careers.

By allowing the students to self-assess their own level of strength when it comes to scientific topics, an understanding of their own perceived levels of confidence with scientific activities can be found.[9] Survey questions regarding student's self-efficacy on learning and doing science topics from the Cornell Lab of Ornithology[9] were adapted to measure scientific activity confidence. A Likert scale (1 being strongly disagree and 7 being strongly agree) was utilized in a Qualtrics™ survey. The questions provided insight about a student's perceived self-efficacy level. The Likert scales were collapsed into three categories: 1-3 as disagree, 4 is neutral, and 5-7 is agree. An independent t-test was conducted to determine if there were significant differences between the perceived scientific activity confidence and support scores of white students when compared to students of color (SOC). Differences were considered significant at p-values <0.05.

RESULTS

Demographics

This study included 235 students in total. Due to blank responses, the gender, age, and student classification measures in the study consisted of 234 students. The race measure consisted of 231 students in this study. Students of color (SOC) were defined as students who did not solely identify as white. This included African American, Asian, Native Hawaiian/Pacific Islander, Hispanic/Latin X, American Indian/Alaskan Native, and those of two or more races. It is a diverse classification meant to represent students who are not represented by whiteness. The University in the study is a predominantly white institution (PWI) where the majority of the students are white. In 2022, there were 2,450 faculty (white=70.8%, race other than just white=29.2%) at the institution in the current study. The lack of diversity in teaching faculty may offer some insight into the difference of support found amongst SOC and white students.

Student Demographics			
Measure	**Item**	**Count (n)**	**Percentage (%)**
Gender	Man/Male	125	53.4
	Woman/Female	106	45.3
	Other	3	1.3
Age	18-24	225	96.2
	25-34	7	3.0
	35-44	2	0.9
Student Classification	Freshman	89	38.0
	Sophomore	87	37.2
	Junior	37	15.8
	Senior	21	9.0
Race*	American Indian/Alaskan Native	2	0.9
	American Indian/Alaskan Native, White/Caucasian	1	0.4
	Asian	21	9.1
	Asian, White/Caucasian	5	2.2
	Asian, Native Hawaiian/Pacific Islander	1	0.4
	Asian, White/Caucasian	1	0.4
	Black/African American	12	5.2
	Black/African American, White/Caucasian	4	1.7
	Hispanic/Latinx	12	5.2
	Hispanic/Latinx, White/Caucasian	2	0.9
	Native Hawaiian/Pacific Islander, White/Caucasian	1	0.4
	White/Caucasian	169	73.2

Figure 1. Mean scientific activity confidence values for students based on the corresponding statements. *Each student did not disclose their race, therefore the count for race is n = 231.

Perceived Student Scientific Activity Confidence

The number of white students that completed the survey (168) was more than double the number of SOC (62). Students were asked to rate statements to measure their confidence when it comes to science related activity (**Figures 2 and 3**). Results indicated that there were significant differences amongst the two groups mean confidence values. Students of color produced significantly higher mean values for statements associated with a negative confidence viewpoint on scientific concepts. Two of these statements were: "It takes me a long time to understand new science topics" (M=3.40 for SOC, M = 2.73 for CS; p = 0.001*) and "It takes me a long time to understand how to do scientific activities" (M=3.24 for SOC, M=2.67 for CS; p =0.004*). Responses to the statements "I think I'm pretty good at understanding science topics" (M=5.00 for SOC, M = 5.53 for CS; p = 0.003*) and "I feel confident in my ability to explain science topics to others" (M=4.23 for SOC, M = 4.82 for CS; p =0.003*) indicated white students had perceived a significantly higher positive scientific activity confidence when compared to SOC(**Figure 3**).

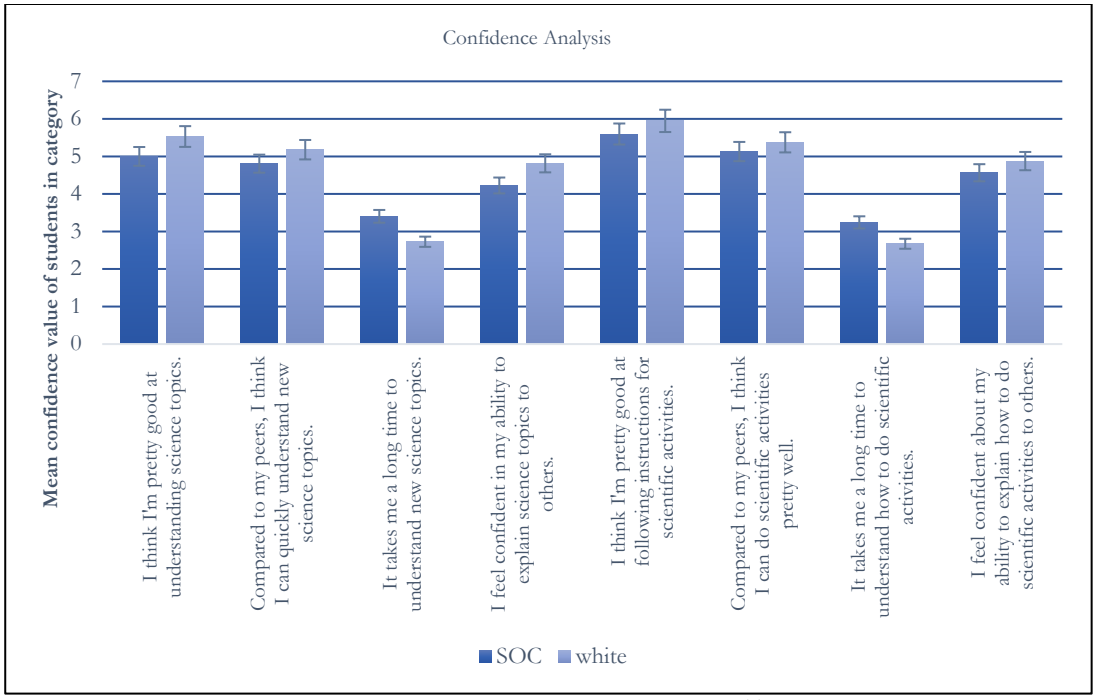

Figure 2. Mean scientific activity confidence values for students based on the corresponding statements. The error bars represent a 95% confidence interval.

Confidence statements	Student Race	N	Mean	Std. Deviation	Std. Error Mean	P-value
I think I'm pretty good at understanding science topics.	SOC	62	5.00	1.32	0.17	0.003*
	white	168	5.53	1.12	0.09	
Compared to my peers, I think I can quickly understand new science topics.	SOC	62	4.81	1.30	0.17	0.042*
	white	168	5.18	1.20	0.09	
It takes me a long time to understand new science topics.	SOC	62	3.40	1.42	0.18	0.001*
	white	168	2.73	1.30	0.10	
I feel confident in my ability to explain science topics to others.	SOC	62	4.23	1.31	0.17	0.003*
	white	168	4.82	1.34	0.10	

I think I'm pretty good at following instructions for scientific activities.	SOC	62	5.60	1.27	0.16	0.05
	white	168	5.95	1.00	0.08	
Compared to my peers, I think I can do scientific activities pretty well.	SOC	62	5.13	1.25	0.16	0.16
	white	168	5.38	1.14	0.09	
It takes me a long time to understand how to do scientific activities.	SOC	62	3.24	1.28	0.16	0.004*
	white	168	2.67	1.31	0.10	
I feel confident about my ability to explain how to do scientific activities to others.	SOC	62	4.56	1.35	0.17	0.13
	white	168	4.88	1.36	0.10	

Figure 3. Descriptive statistics for students as it relates to their science activity confidence (* denotes significance at a p = <0.05). A Levene test was performed, but was not found to be significant at a 95% confidence interval.

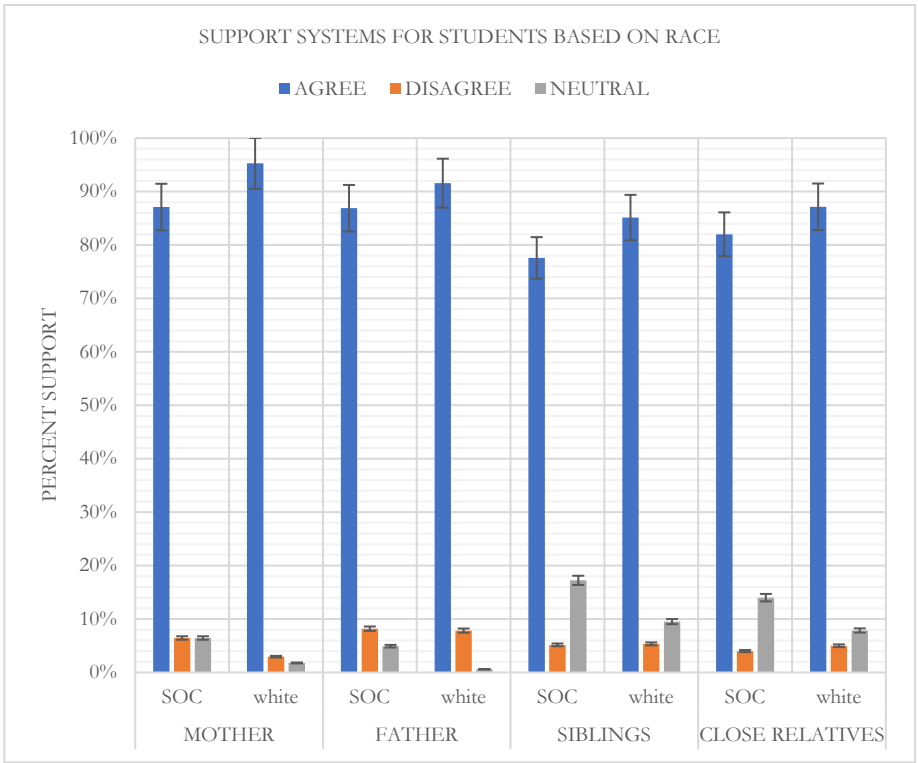

Figure 4. Percentage of student agreement to a statement that family in their life supported them in their choice of major. The error bars represent a 95% confidence interval.

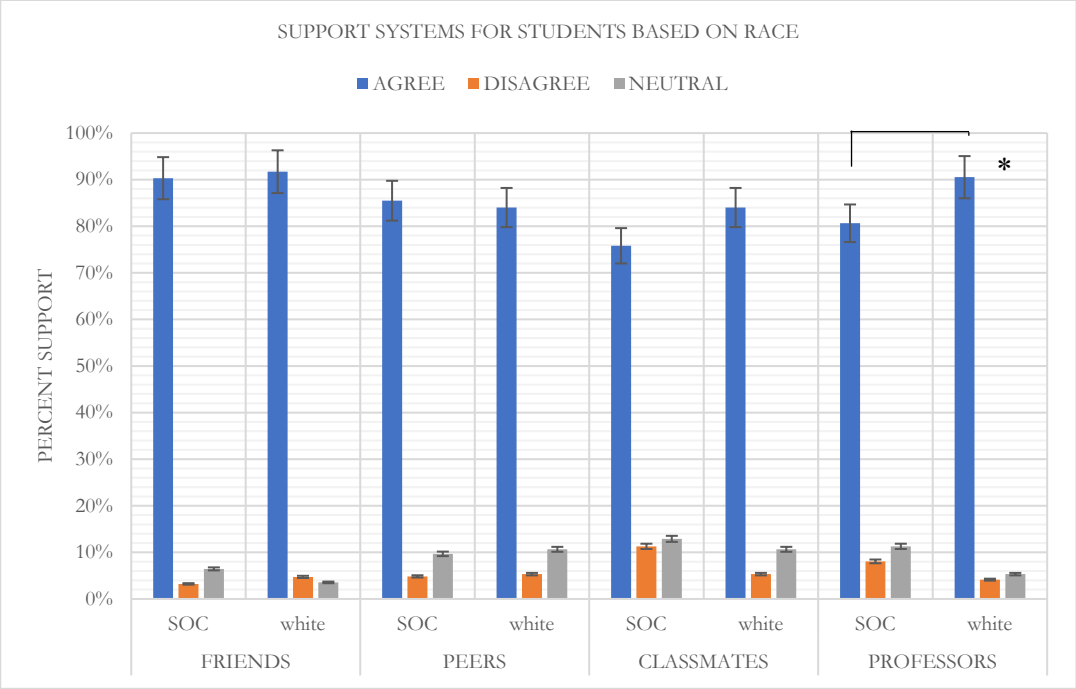

Figure 5. Percentage of agreement based on the support of the following persons regarding their choice of major. The error bars represent a 95% confidence interval.

Support Systems	Student Race	N	Mean	Std. Deviation	Std. Error Mean	P-value
Mother	SOC	62	6.20	1.48	0.19	0.07
	white	169	6.59	1.16	0.09	
Father	SOC	61	6.16	1.38	0.18	0.49
	white	166	6.31	1.46	0.11	
Siblings	SOC	58	5.95	1.65	0.22	0.36
	white	168	6.16	1.47	0.11	
Close Relatives	SOC	50	5.78	1.45	0.20	0.06
	white	140	6.20	1.30	0.11	
Friends	SOC	62	6.06	1.16	0.15	0.29
	white	169	6.25	1.22	0.09	
Peers	SOC	62	5.90	1.24	0.16	0.87
	white	169	5.93	1.34	0.10	
Classmates	SOC	62	5.56	1.70	0.22	0.11
	white	169	5.95	1.33	0.10	
Professors	SOC	62	5.63	1.60	0.20	0.03*
	white	169	6.11	1.22	0.09	

Figure 6. Descriptive statistics for students as it related to their support systems (* denotes significance at a p = <0.05). A Levene test was performed but was not found to be significant at a 95% confidence interval.

Perceived Support

Students were asked if the following persons in their life supported them in their major/educational pursuit (**Figures 4 and 5**). In an analysis of the student's support systems, results indicated that there was a significant difference amongst the support perceived from professors by SOC and white students. White students displayed a higher mean value (M=6.11) in contrast to

SOC (M=5.63). This perceived support value from professors was significantly greater (p =0.03*) in white students than in SOC. Both SOC and white students placed their peers and classmates among the groups that they felt the least support from (**Figure 6**). The mean values when ranking support perceived from their classmates about their choice of major were similar for white students and SOC.

The independent t-test indicated that for these family support variables, there is no significant difference in white students and SOC perceived support from their mother, father, siblings, and close relatives regarding their choice of major (**Figure 6**). Similar to the family perceived support, results suggest that student's perceived support from friends, peers and classmates, there was not a significant difference between white students and SOC. Students support values were overall the highest for mother and father and were the lowest for peers and professors. However, when evaluating students perceived support levels from their professors, the t-test indicated a significant difference (p=0.034*) between how much white students (M=6.11) and SOC (M=5.63) perceived support from them.

DISCUSSION/CONCLUSION

Discrepancies in academic performance of undergraduate students of color (SOC) and their white counterparts in the scientific field could be associated with the support systems around them and their own confidence surrounding science activity. In this study, students in an introductory environmental sciences course communicated their own perceived levels of support and confidence. In both the support and scientific activity confidence results, white student's results yielded more positive outcomes than SOC. It was found that there were significant differences between the two groups pertaining to their perceived level of support from professors and their individual confidence pertaining to STEM related topics.

Upon entering the collegiate environment, many different factors contribute to the success of students in academics. Two key factors examined in this study included scientific activity confidence and support. Science-related confidence is the students "sense of their competence and skill, [and] their perceived capability to deal effectively with various situations".[10] An increase in a student's self-confidence can be correlated with a higher level of academic success.[11] Support "can be conceptualized in terms of the structural components (e.g., social integration: being a part of different networks and participating socially) and the functional components (e.g., different types of transactions between individuals, such as emotional support or favors)".[12] Support is an important factor in the academic setting because it promotes positive reinforcement that motivates students to try their best in school and maintain/exceed their current performance.[13]

Based on a study by Quintana et al.,[1] a connection was found between race and the levels of support in undergraduate students. Some groups have a higher chance of performing better in academic settings than others,[1] which could be due to the abundance of evidence linking better support systems to better academic performance.[14] McKown et al.[15] delves into a series of three studies conducted at primary schools. These studies examined different racial groups of students and the relationship between what their teachers expected of them and how this related to their academic performance. In this paper, researchers concluded that when the teachers expected more from students, they taught more enthusiastically and provided "higher quality instruction". Subsequently these students would become influenced based on the expectations from teachers and as a result would respond by either working harder to meet the higher standard or becoming demotivated in the face of prejudice and low expectations.[15] In reference to the results above, the SOC in this study ranked the perceived support from professors when it comes to their choice of major significantly lower than that of the white students. This could provide insight into an academic achievement gap that could result for SOC where they must work harder against what is perceived to be less support from their professors.

Science activity confidence and support systems are connected. The more positive a student's support system tends to be, the better their scientific confidence will be when approaching difficult or new topics.[16] Confidence is a factor that is strongly associated with high performance in all aspects of life.[11] Those who tend to hold onto higher perceived self-confidence seem to attribute better qualities in terms of likeability, self-esteem, performance, and competence.[10] Three studies conducted around "self" by the University of New York at Buffalo, determined that college students with considerable self-confidence are attributed with more positive future academic outlooks.[10] Our results indicated that SOC were repeatedly responding with significantly lower values for scientific activity confidence statements compared to their white classmates. The lower the student's confidence surrounding these topics, the more students may struggle to achieve the same level of academic success as other students within the scientific field.[17]

Such disparities may possibly lead to more SOC having harder times navigating the same environments as their white counterparts. The support system of a student can be a major indicator of their success in school and academic environments.[8] This discrepancy and lack of support could lead to gaps in terms of science activity confidence and quality education for SOC. Higher dropout rates, lower performance overall, and alienation of SOC in higher education could result. Along with some of the other factors that SOC must overcome in collegiate settings, these additional aspects can continue to make it difficult for them to

successfully enter, succeed, graduate, and find jobs.[18] "Only with a keen understanding of the sources of ethnic disparities in academic achievement can social policies be designed to promote greater equity and by extension, optimal youth development and a healthy society".[19]

Some limitations in this study include the classification of students in the course surveyed, the small number of SOC (n=62) within the overall population surveyed, and a lack of open-ended survey questions. In an introductory environmental science course, most students were underclassmen and fell into the freshman and sophomore classification. If the study included more students of higher classifications, it may have provided better insight regarding support in collegiate settings from students who were further along in their academic career. The small amount of SOC in the sample size of the data may have resulted in an underpowered study. Additionally, more in depth survey questions that were open ended may have provided information regarding why students did not feel supported or confident regarding the topics asked. There were also other factors of support commonly found in collegiate settings that were not analyzed in this study, which may have had an impact on student support scores such as family finances, tutors, academic advisors, teaching assistants, and other faculty.

Something worth noting is that even if many of the results did not yield significant differences, perhaps due to a low sample size, white students consistently had a trend of better/more positive ratings than SOC. This demonstrates a consistent difference that may be worth exploring for future research. Some other implications from this study that future research may call to answer is the examination of study groups, mentor programs, and monetary support from family specifically on the effect of support. Although these factors were not observed in this study, they may have a profound effect on students support systems in higher education. This may call for a reanalysis of the term "support" and the many layers of it impacting students' lives. This study was also conducted at a large PWI, and analysis for support and confidence at historically Black colleges or universities, other minority serving institutions, and smaller institutions may offer different results that are worth investigating.

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REFERENCES

1. Quintana, Stephen M., and Lana Mahgoub. (2016) "Ethnic and Racial Disparities in Education: Psychology's Role in Understanding and Reducing Disparities." Theory Into Practice 55, no. 2: 94–103. *https://doi.org/10.1080/00405841.2016.1148985*.
2. Bhutta, Neil, Andrew C. Chang, Lisa J. Dettling, and Joanne W. (2020) Hsu with assistance from Julia Hewitt. "Disparities in Wealth by Race and Ethnicity in the 2019 Survey of Consumer Finances,". *https://www.federalreserve.gov/econres/notes/feds-notes/disparities-in-wealth-by-race-and-ethnicity-in-the-2019-survey-of-consumer-finances-20200928.html*.
3. Ransaw, Theodore S., and Richard Majors, eds. (2020) Teaching to Close the Achievement Gap for Students of Color: Understanding the Impact of Factors Outside the Classroom. New York: Routledge. *https://doi.org/10.4324/9781003093855*.
4. Robinson, Sean, and Veronica Franklin. (2011) "Working Against the Odds: The Undergraduate Support Needs of African American Women." In Diversity in Higher Education, edited by Crystal Renée Chambers, 21–41. Emerald Group Publishing Limited. *https://doi.org/10.1108/S1479-3644(2011)0000008005*.
5. Fuse, Akiko and Bergen, Michael. (2018) "The Role of Support Systems for Success of Underrepresented Students in Communication Sciences and Disorders," Teaching and Learning in Communication Sciences & Disorders: Vol. 2: Iss. 3, Article 3. *https://doi.org/10.30707/TLCSD2.3Fuse*
6. Phillips, Tina, Norman Porticella, Mark Constas, and Rick Bonney. (2018) "A Framework for Articulating and Measuring Individual Learning Outcomes from Participation in Citizen Science." Citizen Science: Theory and Practice 3: 3. *https://doi.org/10.5334/cstp.126*.
7. London, Bonita, Lisa Rosenthal, Sheri Levy, and Marci Lobel. (2011) "The Influences of Perceived Identity Compatibility and Social Support on Women in Nontraditional Fields During the College Transition." Basic and Applied Social Psychology 33: 304–321. *https://doi.org/10.1080/01973533.2011.614166*.
8. Sledge, Lanita. (2012) "Get Your Education: Family Support for African-American College Students" 4 : 22.
9. Cornell Lab of Ornithology. (2015) "Developing, validating, and implementing situated evaluation (DEVISE) instruments scales." Ithaca, NY.
10. Shrauger, J. Sidney, and Mary Schohn. (1995) "Self-Confidence in College Students: Conceptualization, Measurement, and Behavioral Implications." Assessment 2, no. 3 : 255–278. *https://doi.org/10.1177/1073191195002003006*.
11. Erwin, T. Dary, and Karlease Kelly. "Changes in Students' Self-Confidence in College." Journal of College Student Personnel 26 (1985): 395–400.
12. Reblin, Maija, and Bert N. Uchino. (2008) "Social and Emotional Support and Its Implication for Health." Current Opinion in Psychiatry 21, no. 2 : 201–205. *https://doi.org/10.1097/YCO.0b013e3282f3ad89*.

13. Thayer, Robert E. (1973) "Do Low Grades Cause College Students to Give Up?" The Journal of Experimental Education 41, no. 3 : 71–73.
14. DeFauw, Chloe, Katelyn Levering, Rosemary Msipa, and Samuel Abraham. (2018)"Families' Support and Influence on College Students' Educational Performance." Journal of Education and Development 2 : 11. *https://doi.org/10.20849/jed.v2i1.312*.
15. McKown, Clark, and Rhona S. Weinstein. (2008)"Teacher Expectations, Classroom Context, and the Achievement Gap." Journal of School Psychology 46, no. 3 : 235–261. *https://doi.org/10.1016/j.jsp.2007.05.001*.
16. Good, Catherine, Joshua Aronson, and Michael Inzlicht. (2003)"Improving Adolescents' Standardized Test Performance: An Intervention to Reduce the Effects of Stereotype Threat." Journal of Applied Developmental Psychology 24, no. 6 : 645–662. *https://doi.org/10.1016/j.appdev.2003.09.002*.
17. Acosta-Gonzaga, Elizabeth. (2023) "The Effects of Self-Esteem and Academic Engagement on University Students' Performance." Behavioral Sciences 13, no. 4 : 348. *https://doi.org/10.3390/bs13040348*.
18. Mina, Liliana. (2011)"Can I Succeed? Challenges African-American Women Face in Technology-Driven College Classrooms." In Diversity in Higher Education, edited by Crystal Renée Chambers, 43–57. Emerald Group Publishing Limited. *https://doi.org/10.1108/S1479-3644(2011)0000008006*.
19. McKown, Clark, and Michael J. Strambler. (2009)"Developmental Antecedents and Social and Academic Consequences of Stereotype-Consciousness in Middle Childhood." Child Development 80, no. 6 : 1643–1659. *https://doi.org/10.1111/j.1467-8624.2009.01359.x*.

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PRESS SUMMARY

Undergraduate student support systems and individual confidence in science courses have been linked to better academic performance among college students. As the topics of diversity and inclusion continue to draw the attention of the collegiate, the question of equity surrounding supportive learning environments in higher education comes into focus. Students (n = 235) were asked to complete a survey with the intent to measure the differences in support and confidence among white students and students of color (SOC). The findings demonstrated that white students may have had access to stronger support systems and had higher science activity confidence levels than SOC based on survey responses. As a result, higher dropout rates, lower performance overall, and alienation of these students in higher education environments could occur.

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