# AP® Seminar Performance Task 2: Individual Research-Based Essay and Presentation

## Directions and Stimulus Materials

January 2026

# Contents

# Introduction

This performance task, highlighted in bold below, is one of three parts of the overall assessment for AP Seminar, and one of two performance tasks. The assessment for this course comprises the following:

Performance Task 1: Team Project and Presentation

- Component 1: Individual Research Report
- Component 2: Team Multimedia Presentation and Oral Defense

**Performance Task 2: Individual Research-Based Essay and Presentation**

- **Component 1: Individual Written Argument**
- **Component 2: Individual Multimedia Presentation**
- **Component 3: Oral Defense**

End-of-Course Exam

- Part A: Three Short-Answer Questions (based on one source)
- Part B: One Essay Question (based on four sources)

The attached pages include the directions for Performance Task 2, information about the weighting of the task within the overall assessment, and detailed information as to the expected quantity and quality of work that you should submit.

Also included are the stimulus materials for the task. These materials are theme-based and broadly span the academic curriculum. After analyzing the materials, develop a research question that suits your individual interest based on a thematic connection between at least two of the stimulus materials. Your research question must be rich enough to allow you to engage in meaningful exploration and to write and present a substantive, defensible argument.

# AP Seminar Performance Task 2: Individual Research-Based Essay and Presentation

## Student Version

**Weight:** 35% of the AP Seminar score

## Task Overview

This packet includes a set of stimulus materials for the AP Seminar Performance Task 2: Individual Research-Based Essay and Presentation.

You must identify a research question prompted by analysis of the provided stimulus materials, gather information from a range of additional sources, develop and refine an argument, write and revise your argument, and create a presentation that you will be expected to defend orally immediately following your presentation. Your teacher will give you a deadline for when you need to submit your written argument and presentation media. Your teacher will also give you a date on which you will give your presentation.

| Task Components | Length | Due Date (fill in) |
|---|---|---|
| Individual Written Argument (IWA) | 2,000 words | |
| Individual Multimedia Presentation (IMP) | 6–8 minutes | |
| Oral Defense (OD) | Respond to 2 questions | |

In all written work, you must:

- Acknowledge, attribute, and/or cite sources using in-text citations, endnotes or footnotes, and/or through bibliographic entry. You must avoid plagiarizing (see the attached AP Capstone Policy on Plagiarism and Fabrication and Falsification of Information).
- Adhere to established conventions of grammar, usage, style, and mechanics.

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## Task Directions

1. **Individual Written Argument** (2,000 words)

- Read and analyze the provided stimulus materials to identify thematic connections among the sources and possible areas for inquiry.
- Compose a research question of your own prompted by analysis of the stimulus materials. Your question must relate to a theme that connects at least two of the stimulus materials.
- Gather information from a range of additional sources representing a variety of perspectives, including scholarly work.
- Analyze, evaluate, and select evidence. Interpret the evidence to develop a well-reasoned argument that answers the research question and conveys your perspective.
- Throughout your research, continually revisit and refine your original research question to ensure that the evidence you gather addresses your purpose and focus.
- Identify and evaluate opposing or alternate views and consider their implications and/or limitations as you develop resolutions, conclusions, or solutions to your research question.

### Required Checkpoints

While you are working on your research for the IWA:

- you will be required to submit evidence of the original sources that you have found and read to your teacher.
- your teacher will arrange a time for you to discuss your research and sources with them. For that discussion you should be prepared to talk about your sources, and the perspectives and ideas you have found in your research.

When you begin planning your argument you will also be required to present and discuss your argument outline with your teacher. For that presentation you should explain your decisions about the structure of your paper and what information you decided to include.

- Compose a coherent, convincing and well-written argument in which you:
  - Explain the significance or importance of your research question by situating it within a larger context.
  - Establish a well-organized argument that links claims and evidence and leads to a specific and plausible conclusion, resolution or solution that addresses your research question.
  - Integrate at least one of the stimulus materials as part of your argument. (For example, as providing relevant context for the research question or as evidence to support relevant claims.)
  - Evaluate different perspectives by considering objections to them, and their limitations and/or implications.
  - Include relevant evidence from credible sources to support your claims. You should include evidence from scholarly work.
  - Cite all sources that you have used, including the stimulus materials, and include a list of works cited or a bibliography.
  - Use correct grammar and a style appropriate for an academic audience.
- Abide by the 2,000-word limit (excluding footnoted citations, bibliography, and text in figures or tables). Word count does include titles, sub-headings, and in-text citations.
- Remove references to your name, school and teacher.
- Upload your document to the AP Digital Portfolio as directed by your teacher.

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2. **Individual Multimedia Presentation** (6–8 minutes)
   - Develop and prepare a multimedia presentation that will convey the argument from your final paper to an educated, non-expert audience.
   - Be selective about the information you choose for your presentation by focusing on key points you want your audience to understand.
   - Design your oral presentation with supporting visual media (e.g., presentation slides, a poster, a website), and consider audience, context, and purpose.
   - Prepare to engage your audience using appropriate strategies (e.g., eye contact, vocal variety, expressive gestures, movement).
   - Prepare notecards or an outline that you can quickly reference as you are speaking so that you can interact with supporting visuals and the audience.
   - Rehearse your presentation in order to refine your design and practice your delivery.
   - Check that you can do the presentation within the 6- to 8-minute time limit.

   - Deliver a 6- to 8-minute multimedia presentation in which you:
     - Contextualize and identify the importance of your research question.
     - Explain the connection between your research and your analysis of the stimulus materials.
     - Deliver a well-organized argument that connects claims and evidence.
     - Incorporate and synthesize relevant evidence from various perspectives to support your argument. Make sure you cite or attribute the evidence you use to support your claims (either orally or visually).
     - Offer a plausible resolution(s), conclusion(s), and/or solution(s) based on evidence and consider the implications of any suggested solutions.
     - Engage the audience with an effective and clearly organized presentation design that guides them through your argument.
     - Engage the audience with effective techniques of delivery and performance.

3. **Individual Oral Defense**

   Defend your research process, use of evidence, and conclusion(s), solution(s), or recommendation(s) through oral responses to two questions asked by your teacher. Be prepared to describe and reflect on your process as well as defend and extend your written work and oral presentation. Make sure you include relevant and specific details about your work in your answers.

## Sample Oral Defense Questions

Here are some examples of the types of questions your teacher might ask you during your oral defense. These are *examples only*; your teacher may ask you different questions, but there will still be one question that relates to each of the following two categories.

1. **Reflection on the Research Process**
   - How did some preliminary information you gathered inform your research?
   - What evidence did you gather that you didn't include? Why did you choose not to include it?
   - How did your research question evolve as you moved through the research process?
   - Did your research go in a different direction than you originally expected?

- What information did you need that you weren't able to find or locate?
- How did you approach and synthesize the differing perspectives in order to reach a conclusion?

2. **Extending Argumentation through effective questioning and inquiry**
   - What additional questions emerged from your research? Why are these questions important?
   - What are the implications of your findings to your community?
   - How is your conclusion in conversation with the body of literature or other research sources you examined?
   - How did you use the conclusions or questions of others to advance your own research?

## AP Capstone™ Policy on Plagiarism and Falsification or Fabrication of Information

A student who fails to acknowledge the source or author of any and all information or evidence taken from the work of someone else through citation, attribution or reference in the body of the work, or through a bibliographic entry, will receive a score of 0 on that particular component of the AP Seminar and/or AP Research Performance Task. In AP Seminar, a team of students that fails to properly acknowledge sources or authors on the Team Multimedia Presentation will receive a group score of 0 for that component of the Team Project and Presentation.

A student who incorporates falsified or fabricated information (e.g. evidence, data, sources, and/or authors) will receive a score of 0 on that particular component of the AP Seminar and/or AP Research Performance Task. In AP Seminar, a team of students that incorporates falsified or fabricated information in the Team Multimedia Presentation will receive a group score of 0 for that component of the Team Project and Presentation.

## AP Capstone Policy on Use of Generative Artificial Intelligence (AI)

### DEFINITION OF GENERATIVE AI IN AP CAPSTONE COURSES

Generative AI tools use predictive technology to produce new text, charts, images, audio, video, etc. This includes not only ChatGPT and similar Large Language Models (LLMs), but also many writing assistants or plug-ins that are built on this or similar AI technologies.

### POLICY ON ACCEPTABLE GENERATIVE AI USE IN AP CAPSTONE COURSES

Generative AI tools must be used ethically, responsibly, and intentionally to support student learning, not to bypass it. Accordingly, all performance tasks submitted in AP Seminar and AP Research must be the student's own work. While students are permitted to use generative AI tools consistent with this policy, their use is optional and not mandatory.

Students can use generative AI tools as optional aids for exploration of potential topics of inquiry, initial searches for sources of information, confirming their understanding of a complex text, or checking their writing — but not rewriting — for grammar and tone. However, students must read primary and secondary sources directly, perform their own analysis and synthesis of evidence, and make their own choices on how to communicate effectively both in their writing and presentations. Students may not use generative AI tools to write or create their assignments for them. It remains the student's responsibility to engage deeply with credible, valid sources and integrate diverse perspectives when working on the performance tasks. Students must complete interim "checkpoints" with their teacher to demonstrate genuine engagement with the tasks.

The following table describes what constitutes acceptable use of generative AI at different phases of the work to complete the performance tasks.

| Phase of Work | Acceptable Use | Not Acceptable Use |
|---|---|---|
| Exploring ideas to develop and refine an area of inquiry | Using generative AI tools to get a sense of existing debates on an issue, potential sub-topics, or what is generally already widely known about a topic. | Taking the output of generative AI tools uncritically, such as using AI to generate a research question or thesis, without engaging with the actual research or relying solely on generative AI as a source of information about a topic |
| Finding sources | › Using generative AI to find authors, organizations, publications, or sources that may be pertinent to the area of inquiry, so that the student can then locate and read those perspectives directly.<br>› Asking for recommendations on related sources to further explore the topic or address gaps in research.<br>**NOTE:** Not all AI tools are the same in terms of the likelihood they will provide output with credible sources. For example, AI-powered search engines for research databases draw from vetted sources, whereas ChatGPT does not necessarily differentiate. Students must review output with a skeptical, critical eye to be sure any suggested sources are real, credible, and relevant to their inquiry. | Using a list of sources generated by AI without going to the original sources and reviewing the content. |
| Summarizing and/or interpreting sources | Using generative AI to help develop understanding of complex texts by:<br>› Requesting help with understanding complex vocabulary or sentence structures in a source.<br>› Asking for clarification on a confusing concept or passage in a source.<br>**NOTE:** Students should <u>always</u> read the original text of the sources they intend to use to ensure they are accurately understanding and utilizing the evidence from those sources in their work | › Generating a summary or paraphrasing of the source instead of reading it.<br>› Requesting direct quotes or citations from a source to use as evidence without independently identifying them.<br>› Copying and pasting AI generated source summaries into the final draft. |

*(continues)*

| Phase of Work | Acceptable Use | Not Acceptable Use |
|---|---|---|
| Synthesizing ideas and information from sources into a literature review, report, or argument | No acceptable use.<br><br>**NOTE:** Students will be asked questions in either their PREP-based in-progress meetings (AP Research) or in the checkpoints (AP Seminar) to ensure they have done this work themselves. | Asking generative AI to:<br><br>› Compare or contrast sources and/or generate a review of literature.<br><br>› Synthesize common or contrasting elements from within a source or across multiple sources.<br><br>› Develop statements or paragraphs that put sources in conversation. |
| Developing an aligned method for their Research **(AP Research only)** | Summarizing commonly used methods in discipline-specific fields or reviewing benefits and drawbacks of different generic methods or methodologies.<br><br>**NOTE:** Students will be asked questions in their PREP-based in-progress meetings (AP Research) to ensure that they have done this work themselves. | Using generative AI to determine the appropriate method for an individual student's research and/or providing rationales for a specific method. |
| Producing, summarizing and/or interpreting data **(AP Research only)** | No acceptable use.<br><br>**NOTE:** Students will be asked questions in their PREP-based in-progress meetings (AP Research) to ensure that they have done this work themselves. | › Using generative AI to generate data (this would count as falsified and/or fabricated data). *The only exception would be if use of generative AI tools is the subject of the inquiry. In this case, using generative AI to generate data would be part of the method.*<br><br>› Using AI to summarize or discuss their results or data. |
| Developing displays of data **(AP Research only)** | Using generative AI to create charts/graphs or other representations of data collected and assembled by the student. | Using generative AI to produce or generate the data itself. *See exception noted above.* |
| Drafting or outlining a paper | Seeking guidance on general best practices in how to structure a research paper, essay, or report.<br><br>**NOTE:** Students will be asked questions (on the reasoning underpinning their choices for structure and content) in either their PREP-based in-progress meetings (AP Research) or the checkpoints (AP Seminar) to ensure that they have done this work themselves. | › Asking generative AI to produce an outline or draft of a specific paper.<br><br>› Requesting generative AI to write all or part of the paper.<br><br>› Using writing generated by AI in the final draft. |

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| Phase of Work | Acceptable Use | Not Acceptable Use |
|---|---|---|
| Revising a paper | › Using spell or grammar checkers.<br>› Asking for feedback on style and tone (students must make deliberate choices on what feedback to incorporate). | › Accepting AI-generated suggestions for revisions of written work without critically evaluating such contributions.<br>› Incorporating into student submissions new sections of text suggested by generative AI. |
| Creating Citations / Bibliography | › Seeking guidance on how to cite or check citations.<br>› Generating a draft of the bibliographic listing of citations or checking the format of a student-generated draft of the bibliographic listing of citations. | › Using AI to generate citations without having directly studied the original sources.<br>› Relying on generative AI to create the bibliographic listing of citations without then checking the accuracy of the format. |
| Developing Presentations | › Seeking general guidance on effective presentations.<br>› Generating initial ideas for key points, sequence, or visuals for presentations. | › Uncritically using AI to produce the key points, visuals, or structure for presentations.<br>› Using AI to generate a script that is memorized or read for the presentation. |
| Preparing for Oral Defense | No acceptable use. | Using AI to generate possible answers to potential oral defense questions (and memorizing or reading them). |

## REQUIRED CHECKPOINTS AND AFFIRMATIONS

To ensure students are not using generative AI to bypass work, students must complete interim "checkpoints" with their teacher to demonstrate genuine engagement with the tasks. **AP Seminar and AP Research students will need to complete the relevant checkpoints successfully to receive a score for their performance tasks. Teachers must affirm, to the best of their knowledge, that students completed the checkpoints authentically in the AP Digital Portfolio. Failure to complete the checkpoints will result in a score of zero on the associated task**.

- In AP Seminar, teachers assess the authenticity of student work based on checkpoints that take the form of short conversations with students during which students make their thinking and decision-making visible (similar to an oral defense). These checkpoints should occur during the sources and research phase (IRR and IWA), and argument outline phase (IWA only).
- In AP Research, students must complete "checkpoints" in the form of in-progress meetings and work in the Process and Reflection Portfolio (PREP).

AP Seminar and AP Research teachers are also required to affirm, to the best of their knowledge, that the student's final submission is authentic student work.

College Board reserves the right to investigate submissions where there is evidence of the inappropriate use of generative AI as an academic integrity violation and request from students copies of their interim work for review.

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# Spaces of consumption, connection, and community: Exploring the role of the coffee shop in urban lives

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ABSTRACT

Coffee shops have been described as 'third places' in urban lives separate from the work and home, providing places for people to meet, relax and develop connections. However, the growing presence of coffee shops in the urban landscape has meant that they increasingly take on a wider range of roles, becoming spaces of both leisure and work but also providing spaces of sociality in which people can develop connections, and potentially communities. The roles of coffee shops in five cities in England are explored in order to consider how they can be understood not only as spaces of consumption, but spaces which facilitate connection in increasingly isolated urban lives, and generate the potential for communities to develop. By understanding the varied ways in which businesses and consumers co-create these spaces, it may be possible to increase their potential as 'spaces of community'.

## 1. Introduction

One of the most successful retail sectors in the UK since the recession, the coffee shop industry has expanded in size and form across the country as people increasingly frequent coffee shops as part of their lifestyles. In 2019 there were over 25,000 coffee shops in the UK with a market value of £10.1 billion, and forecasts suggest this could grow to at least 32,000 outlets and £16 billion by 2025 (Allegra Strategies, 2019). With a ubiquitous presence in urban areas, these places have the potential to play various roles in the communities in which they are embedded; they provide more than just spaces to get a caffeine fix (Henriksen et al., 2013). As Scambler (2013: 68) stated: 'cafes have never been mere buildings within which proprietors and staff take money in exchange for refreshments'. They represent places where individuals can not only experience public familiarity (Blokland, 2017), but can develop ties to people and place, and potentially develop a sense of community. It is also important to recognise that these spaces can also act as sites of conflict depending on where the coffee shop is located, the communities it is embedded in and the community it serves; coffee shops have been seen as indicators of gentrification (Zukin, 2010), and sites of new consumption practices for the middle classes (Ardekani and Rath, 2017). As a consequence, coffee shops can represent spaces of multiple opportunities but also 'constitute the very heart of urbanism today' (Stenseth 2013: 24).

The coffee shop industry has been the focus of growing academic scholarship in terms of considering the role of coffee shops as 'third places', separate from the work and home (Oldenburg, 1999), as well as their different types and uses (Tjora and Scambler, 2013). Yet there remains limited empirical research which considers how they might be understood as places of connection and community, to which this paper aims to respond. The paper explores the roles of coffees shops in cities in England to consider the potential for them to be considered 'spaces of community'. This draws on research which charted the growth and expansion of the coffee shop industry and examined how coffee shops sought to engage and embed themselves in communities. What emerged were a myriad of activities taking place in coffee shops; some driven by businesses themselves, and others where customers made use of the environment that was provided, co-creating communities. For many people coffee shops have become more than places to eat and drink but important spaces of leisure, work and networking. Given their ever-growing presence, it is important to understand their potential to impact on modern urban lives.

## 2. Considering coffee shops and communities

The concept of coffee shops being widely accepted components of urban social life, as places for gathering, social interaction and co-constructed communities is not new (Cowan 2005). The emergence

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and popularity of the 18th century coffee houses in central London as places of debate, discussion and sociability is well explored, highlighting how coffeehouses, allowed men to gather discuss the news, debate ideas and socialise (Morris, 2019). The coffee house became a place where people of different classes (if not genders) could gather, leading them to become informal places of learning (Simon, 2009). Habermas (1989) argued that places like coffee shops provided new arenas in public life, as centres for sociability (Laurier and Philo, 2007).

A more recent investigation of the role of coffee shops was sparked by Oldenburg (1999), who identified them as 'third places', separate from the home and work places, where people would go to spend time to relax, socialise and visit for the 'joys of association'. The third place provides somewhere 'in which people from a diversity of backgrounds combine to expand one another's understanding of the world, and out of the bonds formed there, community takes root' (Oldenburg, 2013: 8). In these third places, such as coffee shops (but also other businesses such as bars, pubs, books shops etc.) it is possible for communities to develop, and they can become arenas for developing social networks (Tjora and Scambler, 2013), and as spaces of care (Warner, Talbot and Bennison, 2012).

A common thread to the work of Cowan (2005), Habermas (1989) and Oldenburg (1999) is that the coffee shops have the potential to provide a place for unregulated talk, and therefore the potential for connections to be made between people who would not otherwise come together; a form of social connectivity (O'Brien, 2017). More recent studies such as Jeffrey et al. (2017) have highlighted how coffee shops in contemporary societies continue to serve a social function, form an important part of urban life (Montgomery, 1997) and can even act as places where new political identities can be formed. However, the extent to which coffee shops provide real 'third places', actually generating conversations, discussions, connections and communities, has been debated. Critics of chain coffee shops such as Starbucks, argue that they do not facilitate meaningful discussion between customers, in part because a large proportion of customers have their coffee to take away. Moreover, coffee shop designs often have lots of isolated tables, and some patrons may frequent the spaces because they do not want to be disturbed (Broadway, Legg and Broadway, 2017). In these cases coffee shops are more places of consumption than of public gathering (Simon, 2009). The rise of technology use (in particular mobile phone and laptop use) has also been noted to reduce the likeliness of social engagement (Broadway, Legg and Broadway, 2017), with modern generations preferring to text rather than talk (Turkle, 2015). Others have suggested the concept of the third place is not valid, as for many people as coffee shops are sometimes places of work, and therefore not distinctly a neutral place separate from the work or home (Sandiford and Divers, 2014).

## 3. Urban change and a sense of community

Part of the discussion around why these 'third places' have become increasingly important in urban lives is that modern urban societies have experienced a loss of community, and increased isolation as people are more mobile and less connected to the places where they live (Putnam, 2000; Jacobs, 1961; Urry, 2007; Beck and Beck-Gernsheim, 2002). Questions have risen over the nature of community in urban spaces due to growing concerns about individualism and isolation (Henriksen and Tjora, 2014). The decline of pubs as a symbol of reduced community interaction in the UK has sparked discussion, highlighting that the closure of these institutions has not only an economic impact, but a social cost as well (Sandiford and Divers, 2014; Orford, et al., 2009).

However, scholars have argued that there is a need for the notion of community to evolve to reflect more modern practices (Van Wynsberghe and Ronaye, 1999; Blokland, 2017), and questioned if the nostalgic notion of community ever existed in the first place (Frederick, 1998). More modern notions of 'community' and the extent retailers can act as 'community fixers' was investigated by Hubbard (2017), highlighting how this was very much dependent on the enthusiasm and engagement of business owners and consumers, in the context of micropubs on the high street. Blokland (2017: 52) noted how 'everyday affiliations and sociabilities through which people practice community and develop a sense of identification and belonging cannot be captured in the traditional sense of community'.

## 4. The changing nature of community

Sociologists have long debated the changing nature of community and its importance in urban spaces. Tönnies (1957) made the distinction between traditional communities, with strong social ties and dependencies between individuals, and modern communities, characterised by weak ties aimed at commercial transactions. Granovetter (1973) highlighted that weak ties were a common feature of urban neighbourhoods. These weak ties might consist of basic encounters from shopping in the local supermarket to visiting a coffee shop (Henriksen and Tjora, 2014), where people join 'the nod line' (Goffman 1963), acknowledging others regardless of whether they are known to each other. Consequently, Blokland (2017:8) argues that there needs to be reflection on the way community is understood, that community 'manifests itself in the details of everyday life' and should be understood as a set of public practices or performances with more focus on the 'fluid encounters' that take place in urban lives. Through repeated 'fluid encounters', recognising others can in turn create a sense of community. Unlike in past notions of community, which were often embedded in neighbourhoods, other notions of urban social ties do not have to be limited to people living physically close together (Henriksen and Tjora, 2014; Blokland, 2017).

Given the integration of the coffee shop into the daily lives of so many people in the UK, they arguably provide potential arenas for urban dwellers to perform community. The activity of the visiting a coffee shop through repeated practices, interactions and interventions can create a sense of belonging and a 'public familiarity' (Blokland, 2017). Scholars have explored different types of coffee shops (Scambler, 2013; Ferreira, 2016), as well as their varied usages: for refuge; to get a caffeine fix; for work; entertainment; refuelling, or a mixture (Scambler, 2013; Henriksen et al., 2013; Laurier and Philo, 2006a; Woldoff et al., 2013). In particular, Henriksen et al. (2013) highlight that the diversity of coffee shop users, and what can potentially make coffee shops successful as third places is that they can provide both routine and a sense of belonging, providing sites of 'ordinary cosmopolitanism' (Skrbis and Woodward, 2007), and can contribute to 'liveable urban streetscapes' (Harvey and Autumn-Hall, 2015).

Fundamental to the issues explored in this paper, Tjora (2013) explores the notion of 'communal awareness' to show how the coffee shop can be more than a meeting place. Tjora (2013:122) argues that 'community is developed and maintained through various practices of café users through different communal interactions', where the formal becomes intertwined with more personal, through sociability. Other studies of coffee shops have considered them in the context of urban multiculture demonstrating how the sharing of coffee shop spaces can be enabling (Jones et al. 2015) and how they represent places of sociability (Lin, 2012; Hall, 2012; Shapira and Navon, 1991). As Tjora (2013: 122) argued, 'with an increasing number of cafes and coffee shops, at least in many urban communities, there is hope for a developed and maintained communal awareness'.

While there have been efforts to consider the economic impact of coffee shops on the local economy (Wrigley and Lambiri, 2015; DCLG, 2013), the ways in which they interact with their local communities has yet to be considered in such depth. Henriksen and Tjora (2014: 2122) argue that discussions of communities (and how they change), particularly the notion of 'weak ties' need to be grounded in more detailed empirical analyses to begin to capture 'the very complex nature of social life'. This paper seeks to demonstrate that in addition to the 'weak ties' that may be provided through coffee shops use they also have the

potential to generate 'meaningful encounters' (Valentine, 2008), and that they have the potential to provide spaces for more than just the 'low level sociability' (Laurier and Philo, 2006b). As this paper explores, they can be more than simply places of consumption, but also places of connection, sociality, and even community.

Through an empirical analysis of the practices of community in coffee shops, this paper illustrates the ways in which connections and communities can be formed in modern consumptionscapes, either because of active measures of businesses, or through the co-creation of communities with consumers. In doing so, the paper demonstrates how these spaces are well-tailored to the changing nature of urban communities, increasingly characterised by fluid connections, weak ties and transient membership. The coffee shops, and the social dynamics observed, constitute a valuable microcosm of the changing urban landscape.

## 5. Methodology: Investigating the coffee shop industry

To explore the roles of coffee shops in different communities, five cities in England were investigated[1]: Birmingham, Bristol, Coventry, London and Manchester. These cities were selected in order to include a broad geographical spread across England, as well as places with a range of different types of coffee shops as defined by Ferreira (2016). A multi-method approach to data collection took place in each city, using a combination of interviews and observations.

In each city a database of coffee shops was created, and selective sampling was used in order to ensure a range of different coffee shops were included. The selected coffee shops were approached to take part in the research which led to 50 coffee shops being visited across these cities. The coffee shops included 25 chain coffee shops and 25 independent coffee shops, with 40 of these being in central urban locations and 10 located outside the city centre.

In total 100 interviews were conducted, 50 with coffee shops owners, managers, and baristas and a further 50 with consumers; these all took place inside the selected coffee shops. The interviews with coffee shop staff focused on how each coffee shop operated, how they perceived their role in the community, the extent to which they sought to shape community engagement and what the benefits and challenges of doing this were. The consumer element of this research included 20 male and 30 female respondents, with a range of age groups included, but with the largest age groups 21–30 (15 participants and 31–40 (16 participants). Interviews with consumers focused on their experience of the coffee shop, the role of the coffee shop, and in particular on the contribution of the coffee shop to community development and engagement; these included consumers who both purchased their coffee to sit in and for takeaway.

In order to understand more about the role of coffee shops in different locations and to explore their community activities, extensive participant observation took place in over 20 coffee shops in each city over a 15-month period. Selection, again, was selective, using the previously created database. In order to take into account the different temporal patterns of coffee shops (and as a consequence a different consumer base), observations took place in four 1 hour time slots (at 8am, 11am, 2 pm and 4 pm), on both week days and weekends. In addition to extensive observation notes, additional visual data collection such as photographs and details from community boards were collected and included in the analysis. The interviews, observations and visual data were coded to explore the roles of coffee shops in different urban spaces focusing on activities that took place including consumption, the extent of consumer engagement with coffee shop staff and other consumers, who was responsible for instigating such engagement, and the extent to which coffee shops contributed to local communities. In addition to these themes the data revealed insights into key growth drivers for the industry which are explored in the next section.

## 6. Drivers of growth for the coffee shop industry

There are multiple drivers of growth for the coffee shop industry, from changing consumer habits, the impact of the recession, and the growth strategies of coffee shop businesses (Ferreira, 2016). This research suggested that the shift towards frequenting coffee shops rather than pubs was seen as a key driver for industry growth. Pubs have been viewed as third places and potentially valuable social institutions in communities (Sandiford and Divers, 2014), but in recent years have experienced decline. It is estimated the number of pubs may have fallen as 20% between 2000 and 2017 (BBPA, 2018), which has the potential for loss of community associated with these closures (Orford et al., 2009). To some extent, coffee shops appear to be taking over the role previously played by pubs. As one coffee shop owner explained:

> '*We're a bit like your local pub used to be. You can pop in at lunch time for a break from work, relax, have a drink and bite to eat, and if you meet friends you can socialise too.*'

Many respondents touched upon the concept that coffee shops may appear to be more welcoming spaces than pubs or bars. In particular, coffee shops appear more welcoming to women, young people (Thomas, 2006), and to some extent they are more socially acceptable places to frequent, particularly in the daytime. One manager explained that:

> *'It's a lot more diverse, because generally you don't find a lot of single women going into pubs, but they'll think nothing of going into a coffee shop. You obviously don't find a lot of children and young adults going into pubs, but it's a totally normal environment for them to be in the café'.*

Coffee shops then, can provide comparatively welcoming and 'safe' spaces for a larger consumer group than pubs; a point which was acknowledged by a number of consumers in this research with comments that coffee shops were 'more friendly', 'less intimidating' and 'more suitable' for gatherings where children were involved. This shift away from visiting pubs and the growing popularity of coffee shops has been acknowledged by businesses too. Many pubs advertise their coffee offering, attempting to suggest they can be used in the same way as coffee shops, and one pub chain (SA Brains) even has its own coffee shop chain, Coffee #1. The chain is rapidly growing in the UK, and its stores somewhat emulate the pub with their décor (a range of seating arrangements, bookshelves and faux fireplaces), with the exception that instead of a traditional bar, there's a coffee bar.

Aggressive expansion of coffee shop chains has substantially expanded the presence of the industry on the high street and on an ever-increasing range of locations (Ferreira, 2016). Part of this has been felt in the coffee shop chain sector: while the UK has seen the proliferation of Costa Coffee, Starbucks and Caffe Nero across the country, other chains have sought rapid expansion: one example is Coffee #1, which emerged as a regional chain in the South West and Wales from 2001, but had over 83 stores in England at the time of writing (Coffee #1 2017). In addition, there has also been strong growth of independent coffee shops (SCA, 2017). In particular, the specialty coffee shop has been a rising presence in the market. These are places where there is a greater focus on the quality of coffee and its variety of methods of preparation, often referred to as 'third wave' coffee shops (Ferreira, 2015). The success of many independent coffee shops is evidenced by the rise of independent chains emerging in many cities, such as Grind in Manchester, the Department of Coffee and Social Affairs in London, and 200degrees coffee in the Midlands. Many respondents noted the symbiotic relationship between the established chains and other coffee shop business models, as explained by a barista:

> *"Its good fun chain bashing, but we must not lose sight of the fact that without the chains, there would be no specialty coffee industry. There*

[1] The café industry has been growing steadily across the UK, further study is needed to explore developments in Scotland, Wales and Northern Ireland.

*would have been no boom. Without the chains, I don't think the specialty coffee industry as it stands is sustainable, because most people don't come here without having been through the chains first'.*

As a consequence of a rising presence of coffee shops, in particular of specialty coffee shops, there has been a rise in knowledge about coffee and, for some consumers, a desire to drink higher quality coffee, including more single origins and unique blends than are on offer in many of the chains. This has led to growth in other coffee businesses such as independent roasters, and coffee shops with their own roaster. It's estimated there are around 1400 independent coffee roasters in the UK, expected to grow at a rate of around 12% per year (Allegra Strategies, 2015). Commenting on the link between the growth of coffee shops and roasters, one owner states how:

'*There's a nice symbiosis: they wouldn't be where they are without the roasters and the roasters wouldn't be there without the coffee shops*'.

Naturally the creation of new businesses, whether this is a coffee shop or roaster, generates new employment opportunities, and where there is a local population of people with a particular interest in coffee, there is potential for 'coffee communities' or an 'active coffee scene' to be created, as will be explored later in the paper. Increased demand for coffee, and for high quality coffee in particular, has been an important driver of coffee shop growth. However, as is demonstrated throughout the following section of this paper, coffee shops are about much more than just the coffee.

## 7. Exploring the role of coffee shops in communities

While the coffee shops of 18th century London were noted for their role as spaces for communities of men to gather and share news and knowledge and discuss new ideas (Morris, 2019), the modern-day coffee shop has the potential to play a multiplicity of roles depending on its location and operations, representing 'neutral third places that bridge social capital' (Hyra, 2017: 159). Research has shown how people use coffee shops in different ways, from spending time alone in public to an alternative office (Scambler, 2013), but these spaces also have the potential to be used in different ways, in part due to the actions of businesses themselves.

Table 1 provides a list of the activities identified in coffee shops included in this research that indicated connections to others. While they may not represent the majority of coffee shop business activities, it highlights the potential these spaces have for bringing people together and allowing business to foster, and engage with, communities.

While many of these activities were business initiated, there is an element of co-creation with consumers in all of them because they require the participation of both the be successful; co-working spaces or suspended coffee initiatives would only be successful with consumer participation. Co-creation is referred to in different ways across disciplines (Greenhalgh et al., 2016) from the creation of value in business and management studies (Zwass, 2010), to improvement of experiences in science, healthcare and public services (Ramaswamy and Ozcan, 2014). In this research co-creation refers to examples of where the activities required buy-in from both the business and the consumer base to take place, but could be initiated by either group. For example, a themed food event that was prompted by discussions with local consumers, or a photography group that was established by a member of staff to fuel their hobby.

The activities revealed in this research highlight how coffee shops can take on three key roles in relation to communities: facilitating connections, community development and community enrichment, outlined in Table 2. These range from activities that take place through interactions with people who work in the coffee shop, and those who choose to meet there.

It is recognised that a large proportion of customers use coffee shops for takeaway purchases, with many people not seeking to actively engage in any form of community creation, yet even these brief 'fluid encounters' have the potential to provide a connection to local communities for people, with the possibility of greater engagement over time depending on both the actions of businesses and consumers. These tables highlight the range of potential activities that can take place in a coffee shop, and begin to point and some of their varied roles which are explored in more depth in the next section, using examples from this research.

**Table 1**
Coffee shop connections and communities.

| Type of activity | Examples | Business initiated or co-created |
|---|---|---|
| Organised activities | Reading groups | |
| | Study groups | |
| | Food and drinks evenings | |
| | Coffee tasting and brewing events | Business initiated and co-created |
| | Art events | |
| | Live music | |
| | Arts and crafts activities | |
| | Elderly companion group | |
| | Photography group | |
| | Game group | |
| | Science discussion group | |
| Connection to local community | Interaction with staff | Business initiated and co-created |
| | Interaction with other customers | |
| Sustainability | Reduced waste | |
| | Use of coffee grounds | Business initiated |
| | Reduced food waste | |
| | Support of the local economy | |
| Working lives | Co-working spaces | Business initiated |
| | Networking events | |
| Themed coffee shops | Board game coffee shops | |
| | Cat café | Business initiated |
| | Children's/play coffee shops | |
| External engagements | Speaking in local schools | Business initiated and co-created |
| | Suspended coffee | |
| | Donation to charity events | |

Source: authors.

**Table 2**
Coffee shop roles.

| Role | Description |
|---|---|
| Facilitating connections | Through interaction with staff |
| | Through interaction with other customers |
| | Meeting with others |
| Community development | Establishing activities and events that prompt interaction |
| | Being conducive for consumers to establish community activities |
| | Designing a business model around particular communities |
| Community enrichment | Donation of food and drinks either through suspended coffee or to events and charities |
| | Interaction with local people |
| | Efforts in sustainability |

Source: authors.

## 8. Supporting existing communities: The 'common interest' groups

Beyond the desire to connect with individuals, for some businesses the connection to the local community was at the heart of their business model, as one manager highlighted:

'*Our company motto if you like, it's the 3Cs, coffee, customer service and communities, they are our three really important things*'.

While this may sound like PR-speak, observations of the coffee shop in question confirmed that it did seem to be somewhere that was used like a community space, in part due to the large size of the premises. One afternoon, in addition to regular customers using the coffee shop, many of whom visited with children and made use of the toys and games available, there was also a knitting group, two study groups, an organised meetup of photographers, and a new installation of art for sale produced by a local artist installed on the wall. The efforts of this business were noted by some its consumers, one of which who commented:

'It*'s nice to come to a coffee shop where they try to bring people together a bit, I've ended up making a few friends in this place, after a conversation with someone about the book I was reading. It's that kind of place where people are friendly enough that you don't mind starting a conversation*'.

Some coffee shops developed their activities with an explicit community focus, organising events in their space to cater for different groups of consumers. This ranged from reading groups, coffee tasting sessions, cider and cheese evenings, to scientific discussion groups. For these coffee shops, the idea of developing community activities was a logical way to enhance the customer offerings, potentially increase sales, and have their business used as a community space. As one manager explained:

'We *sort of came up with the idea that it's a village hall in the city centre, so it's just a space people can come and use for stuff… we use the term urban village hall, we didn't just want business workers*'.

Of course, not all coffee shops have space to offer to people for different activities, but even in the smallest of coffee shops explored it was possible to get groups of people together for events. One consumer explained how they had attended a standing room only event at a very small coffee shop about coffee brewing, and that actually being made to stand next to people made conversation easier:

'*I think you're less likely to just start a conversation with a random person at another table, but because we were all there for that particular event I knew people had at least some similar interests so there was already something to talk about, and we weren't separated by the furniture*'.

Of the coffee shops included in the study, 85% had regular group meetups on their premises, ranging from reading groups and cake clubs to language groups. The variety tended to be higher in independent coffee shops, with more flexibility about spaces that could be used, but chain coffee shops also saw community activities on their premises as a positive aspect of their business.

There is a broad spectrum of coffee shop types (Ferreira, 2016) but one particular group designs their coffee shops with specific communities in mind. These are businesses that are designed to appeal to particular communities and potentially facilitate people with similar interests to meet. Examples of these interests include cycling, board games, and even cats.

'*So we're a coffee shop and a cycling shop in one, we have a cycle repair service and things like that too. Because of so many people commuting by bicycle there's a big cycling community and people know if they come here they can get great food and drinks, but also wax lyrical about bicycles if they want, or pick up something they need, or just have somewhere to feel comfortable walking in wearing lycra*'.

While these types of business do target a particular group of consumers, often owners commented on how other patrons were sometimes intrigued by the nature of the coffee shop, and might visit as something different to do, but ended up being regulars. This was confirmed by some consumers, for example one in a board game coffee shop commented:

*'We came in here initially a couple of years ago because it looked quirky and we thought playing a board game for a bit of a break from the cold, but actually we've ended up coming here regularly, joining some group events and I even won a small tournament once'*.

## 9. Building inclusive communities

While the aforementioned coffee shops sought to develop new communities, and host existing ones within their walls, others took action to have a positive impact on the wider local community. 'Suspended coffee' was offered in a small number of independent coffee shops; this is where customers can pay for an extra food or item of drink, which can then be given to someone in need who can't afford it, as one manager explained.

'We *do suspended coffee, and the suspended coffees do get used, it's just a small way for us and our customers to help other people in the area.*'

A manager from a chain coffee shop gave talks in local schools about food sustainability:

'*We've just begun to do bits of work with schools, our manager goes to talk to kids about where the products come from etc. It's just another way of engaging with the community.*'

There were also efforts to add vibrancy to the local area, such as holding tasting events, local markets, showcasing local artists and organising salsa nights. Many coffee shops recognised the benefit for their business if they were seen to be active in the local community, as it meant they were viewed by local people as 'part of community', who were therefore more likely to spend time (and money) there. A common point of discussion with coffee shop owners was how they are important contact points for people who might be new to the community, or are who just want to spend some time 'alone in public'.

*'We often get people come in and say hey we've just started working down the road, and we end up having lots of conversations which introduce people to things in the area… when we have time to talk to customers that is… in rush hours people tend to just be in and out whether they are new or not'*.

This owner raises an important point, that while coffee shops have the potential to play a multitude of roles, the extent to which these might take place depends on the location, time and individuals involved.

## 10. Weak ties: fluid encounters and coffee shops

For some individuals visiting a coffee shop is a way of building up familiarity to a particular place, developing a routine, building a rapport with the baristas, and maybe even acknowledging other patrons. These 'fluid encounters' facilitate the generation of weak ties to particular communities, particularly if they begin to take place on a regular basis (Blokland, 2017). In part this might be facilitated by seeing the same faces repeatedly, a phenomenon which is somewhat diminished due to the high turnover of staff in many coffee shop businesses (Simon, 2009), but nevertheless featured in many consumer interviews as a reason why people liked visiting coffee shops, even if this was briefly on the way to work:

*'It's nice to start the day with a coffee, and just a brief hello, how are you doing? Usual stuff, chat about the train delays, weather and how busy life is, but it's still nice, just a bit of conversation, it's become part of my routine….helps wake me up a bit too'*.

A repeated point of discussion was how coffee shops provide places for people to connect with others, from parents meeting friends with children, business meetings, students meeting to work together, people getting together bonded by a common interest, or friends taking a break on a shopping trip. It confirms that as previous research has indicated coffee shops, can be considered places of conviviality, as a manager

explained:

*'You get plenty of people that sit on their own for whatever reason, but more often than not you get pairs and groups of people come in, or meet here, it's an easy place to get together, get a quick drink and/or a bite to eat, it's a relaxed atmosphere, and provides a bit of respite from all of that going on out there'.*

Both interviews and observations confirmed that many people do sit alone in coffee shops, often shielded by their mobile phone or laptop from the people around them. Many consumers identified that they went to the coffee shop as a place to be left alone:

*'If I try and sit with a laptop at home, there are people around who'll talk to me, a cat who'll walk over my lap, or the doorbell, or something. Here I can zone out and get on with it'.*

But even in these cases the very fact of being in a coffee shop is for some people a connection to the community, as the brief interaction with staff and the possibility of observing people around them provides a level of 'public familiarity' which may develop in to different types of interactions over time. As explained by one consumer:

'*Sometimes I just need to get out, and this is a place I come to where I can get a bit of peace, I can think for a bit and I might bump into some I know and chat to them, I might now and just sit on my own for a while. I've spent hours in coffee shops on my own for work and relaxation but these kinds of places are flexible to that – that's kind of the point of them I guess.'*

For many coffee shops a high percentage of consumers purchase their drinks and food to go, particularly in the morning. While the focus of activities for these consumers was not likely to be community engagement, there were still consumers who said that it was nice to visit the same place on the way to work each day, reiterating the point of how coffee shops had become part of a routine that felt familiar, and that being recognised as a 'regular' was somehow satisfying, as one consumer explained:

*'They started to remember my order a couple of days after I started working here, I don't even usually have to ask now, they just ask if I want the 'usual'. It's nice, I mean, I know a couple of the baristas by name now. I don't live around here, but I spend a lot of time around here for work, and it's nice to have somewhere to go and feel like you have a bit of a connection …. I'd be really disappointed if this place closed'.*

This suggests that even for small coffee shops with a high takeaway coffee ratio, there is the potential for people visiting to feel a connection to a community through these 'fluid encounters'. Although there were of course others who were just visiting and as such had no connection and no desire for one, but this reinforces the point that coffee shops have the potential for being places of connection, but actually take on a multiplicity of roles for different people.

## 11. Coming together around coffee: tasting and cupping

As aforementioned, the growth in coffee shops has been accompanied by a growing interest in coffee for many consumers. For some business owners, it was a priority to actively create a community for those with an interest in specialty coffee, sharing their knowledge and passion for the product:

*'We hold regular cuppings and tasting sessions for people that are interested. It's a great way for us to get to know our customers a little and they get to learn a bit more about the coffee we serve'.*

Of the independent coffee shops included in this study, 75% offered either classes on different brewing methods or latte art, or coffee cuppings which allow customers to taste different coffees. The remaining 25% said they would be keen to hold similar sessions if there was interest. While this is a very specific form of community, many coffee shops spoke positively about how it was these types of activities which spread knowledge of coffee to other people, fuelling continued popularity of independent coffee shops (and roasters):

*'People sometimes come to these events because they're curious, or because they know someone who likes coffee, and then they end up enjoying themselves, trying new coffees, or new preparation methods, and it encourages them to explore more coffee shops, different coffees and maybe even trying some at home. It's great we get meet lots of people who are excited about what we do, and we get to be enthusiastic about something we're passionate about.'*

Several consumers talked about their experiences at these types of events noting how it provided an opportunity to learn about the coffee, and to meet other people in the area. For many consumers this wasn't an activity they participated in but it was generally viewed as a positive contribution:

*'It's good they have these sorts of things. I don't have the time to go one myself but I can see it must be nice to spend a bit of time actually focusing on how to make this stuff [coffee] properly. And if it keeps the place in business too I'm all for that. I need my coffee supply to keep going'.*

## 12. The café as a co-working space: 'coffices'

Many of the examples discussed so far involved people gathering and interacting in coffee shops, but in reality, many people spend time alone, using the coffee shop as an alternative workspace. Changing working practices, including the growth of freelancing, mobile working and the gig economy have been repeatedly identified as important drivers of demand for space in public to work (Brown, 2013). In many coffee shops across the country individuals armed with their laptop or tablet sit in coffee shops in order to use free wi-fi, work in between appointments, or use the space as an alternative office. The phenomenon of the 'coffice' was mentioned by many managers with mixed feelings. While some saw it as a positive way for people to get out of the home, particularly if they were leading quite otherwise isolated lives, others talked frankly about the negative impact this can have on profits. For some this was actually seen as a barrier to community creation because often people behaved in a very individualistic manner:

*'People get their coffee, sit at the table, open up their laptop and put their headphones on, disconnected from their surroundings somewhat, and that may be what they wanted from their visit here, but no, it doesn't help create a community one bit, some afternoons it can just feel like a sea of laptops'.*

This was confirmed in several coffee shops in this research which had a high percentage of laptop users. For example, one consumer explained:

'*I come here in between meetings, or sometimes to just get out of the office. I don't need to talk to anyone, just get on with work and have some decent coffee*'.

Some coffee shops, however, have embraced the notion of people needing a co-working space. TimberYard, in London, marketed themselves as a coffee shop to work, advertising that they are 'workspace fuelled by purchases'. There were dedicated spaces for people who wish to work at some of its branches, as well as additional rooms for hire when patrons need more a formal work setting. Other coffee shops have established co-working meet up groups for people who work alone but would like to get together to have some company, or potentially expand networks, creating 'liquid networks'. There are a growing range of more formal co-working spaces (where visitors pay to use the space, and often coffee is provided) (Brown, 2017), but costs are often prohibitive, so the coffee shop remains the working space of choice for many. As one consumer explained:

*'The coffee shop is essentially my office, I can't afford a formal office or to rent a desk or anything like that and I just can't work at home all the time. This gets me out of the house and also they have a co-working table gathering once a week so I know a few of the others who are a bit like me… I know I'm taking up a table, but only a small one, and I do buy things throughout my time here, it's just much cheaper than other options.'*

Once again, this highlights how coffee shops have the potential for community creation, in the form of co-working communities, but also provide a bit of solitude for those who seek it, highlighting the multiple roles coffee shops can play at different times.

## 13. A wider view of community: sustainability and local sourcing

Taking a broader perspective of community, many businesses saw their efforts to be more environmentally sustainable as important:

*'We've always made an effort to buy local food where we can, the bread comes from a baker not far from here, and the fresh fruit and veg comes from the market. We're a small independent business and we want to support other independent businesses in the area too'.*

While many independent coffee shops made efforts to buy locally, sometimes this wasn't an option, for logistical and cost reasons. For chain coffee shops, the option to use local suppliers was less prevalent because they were restricted in their supply chain. However, they were keen to highlight how their other efforts in sustainability had a positive impact on the communities they served.

'*We give away our coffee grounds for free, in little bags. People can use them in the garden, so it's helping local people grow more plants, and food*'.

Others saw the efforts to encourage greater recycling of coffee cups, increased use of reusable coffee cups and reducing food waste as having a positive impact on the community. This understanding of community was more about wider society, than the local community itself.

*'We know it's important to try to reduce our impact on the environment where we can, we have the recycling scheme for cups, and we offer a discount for customers than bring their own reusable cup. If we can reduce the amount of waste produced, that's got to be good for the community'.*

## 14. Not only the coffee shop: consumers and community co-creation

Many of the activities that have been explored so far have been driven by the actions of business owners and staff. However, most business owners recognised that many of the community aspects of coffee shops were driven by consumers themselves, and that there was a process of 'community co-creation' between businesses and consumers. The following example demonstrates this well:

'*We get quite a lot of elderly people coming in on their own. Often they sit with their drink, read the newspaper, maybe chat to the staff a bit if they're not too busy. A couple of ladies asked if they could advertise an 'elderly coffee morning' so there was a time when these people could come in and know there was a table of people around to chat if they wanted to. I thought it was a great idea….There's a formal group that meet every Friday but actually lots of them now meet at other points in the week too, sometimes here but I know they meet in other cafes too'.*

Coffee shops in this case provided people with a space to get together, socialise, and in the case of some of those involved, reduce isolation, generating connections between people that wouldn't otherwise have met. In many coffee shops parents and carers would use the coffee shop as local meeting points which in some cases led to more formal groups taking place:

*'We used to meet here every week for an hour for a bit of sanity, we know there are high chairs here and there's space for the pushchair etc, and much needed caffeine. Then after we'd been doing this for a while we ended up setting up an activity group for small children in one of the back rooms after we talked to the manager who thought it was a great idea'.*

While the examples discussed in this paper try to illuminate the varied ways in which there are potential for connections and communities in coffee shops to form, it is recognised that a large proportion of coffee shops serve drinks for takeaway, or for people who want to sit alone, or meet with others they already know. But each of these phenomena has the potential for helping develop ties to the coffee shop, and in turn the local community, whether through just brief interaction with staff, the development of a familiarity with other patrons or more formal activities

## 15. Coffee shops, class and conflict

The article so far has focused on the positive roles of coffee shops in terms of community engagement. However, coffee shops can also act as sites of multiple conflicts, not only in terms of the use of space inside the coffee shop, but also in terms of the impact they have in different locations and how they are received by the existing community, in particular due to processes of gentrification (Smith, 1996; 2010). Coffee shops are not homogeneous (Ferreira, 2016), as a consequence of their geography, and costs involved can be for some people sites of exclusion. More expensive coffee shops which target middle class consumers (Ardekani and Rath, 2017) for example, do not necessarily provide an inclusive opportunity for community, as either chain coffee shops or more traditional cafes.

Depending on where coffee shops are located and the communities they serve, conflicts can take place over how space is used. Examples include conflicts those who wish to use the coffee shop as a peaceful space to work, and those who see it as a place to take their children to. These two activities are not necessarily mutually conducive as one owner explained:

*'We are based in relatively residential area for a city, and this means we get all sorts of people using the café, and sometimes you can see that people get annoyed with each other. If we have a group of talkative teenagers and a couple of people coming in here to try and have a serious meeting, that doesn't always work…… We try to be all things to all people, but at the end of the day if you're going to spend time out in public, you have to get used to the public being around'.*

This type of conflict was seen as minor irritant by many participants, on the basis that consumers continue to choose to spend time in coffee shops regardless, and some found that a certain level of noise can actually be productive for work (Mehta et al., 2012).

A more serious form of conflict relates to the perceived link of coffee shops with gentrification (Zukin, 2010; Slater, 2010; Hyra, 2017). In 2017 a coffee shop in Denver, USA received significant negative media attention for a sign outside which stated that it had been 'happily gentrifying the neighborhood since 2014′, suggesting that the coffee shop was an active agent in the process of gentrification and that this was a positive phenomenon. This received a significantly negative response from the public, including a boycott, and broader complaints about how coffee shops (particularly those at the higher price bands) are typically businesses that appear in neighbourhoods as they become gentrified. In the UK, widespread media attention gathered on the Cereal Killer Café in Shoreditch London after it became the focus of anti-gentrification protests in 2015 with protesters arguing that these types of coffee shops did not serve the local community (Khomami and Halliday, 2015).

These are just examples where coffee shops have been associated

with negative processes of urban change, but the focus and nature of the fieldwork conducted in this research meant that this was not an issue that was explored further, and will require more in-depth investigation in the future. As Blokland (2017) highlighted, approaches to conviviality in urban spaces often focus on the people who are there, rather than those who are not, so there is a need to consider the nature of coffee shops as inclusive and exclusive spaces too. While coffee shops do tend to appear as urban areas become gentrified, the relationship over whether these are a result of, or a factor leading to, gentrification has yet to be sufficiently explored.

## 16. Conclusion

The examples explored in this paper are illustrative of the potential role that coffee shops can play in communities. While many chain coffee shops may appear to be cookie cutter copies of a brand ever present on the high street, there are important social and community dynamics taking place inside their walls. While many people visit the coffee shop for a caffeine fix, a quick bit to eat, or just a bit of respite, there is the potential for these spaces to have a greater impact on their local communities through the co-creation of spaces conducive for communal activities, whether this is the through establishing a group based around a shared interest, an opportunity to work with other people in a similar situation, or just to provide a connection to other people in your local community. Coffee shops are more than just about the coffee, they are important spaces on the urban landscape, and remain important spaces of social connection in modern society. The coffee shop industry in the UK has experienced continued growth for over a decade with estimates this growth is likely to continue for some time. Given this widespread presence, it is important that beyond the economic impact of these businesses the social and cultural impact of the coffee shops for communities is explored too.

While this paper sought to highlight the range of positive ways in which coffee shops can generate community, it is recognised that this is not necessarily universally inclusive, and in terms of the relationship with the processes of gentrification, much greater research is needed to consider the coffee shop experience for different populations, by race, gender and class, for example, to understand how to make these spaces more inclusive. In a similar vein, the observations in this paper, like much of the existing literature on coffee shops and coffee cultures very much reflect the western experience of coffee shop culture. Given the global growth of the coffee shop industry, and the different coffee shop cultures that have emerged around the world (Felton, 2019), future research should also consider the social impact of coffee shops, and roles they can play in these places, and if, how and why they may be similar or different.

Blokland (2017: 162) argued that 'community is a practice of urban setting; it is done through performance'. This research has demonstrated how performance of actions in the coffee shop, from interacting with staff to establishing an interest group, has the potential to generate notions of community. However, it also suggests the contemporary notion of community may need further exploration. It suggests that coffee shops do have the potential to still be considered 'third places', as Oldenburg (1999) has envisaged but that perhaps this might need some re-definition to capture the changing nature of the modern urban consumptionscape, in particular to integrate the nature of work that can take place there, the influence of technology and the wider range of activities that can take place in these spaces. Coffee shops are not necessarily neutral spaces separate from the home and work, but they do provide spaces in which people can spend time in isolation, or with others, and potentially can develop more than 'weak ties' with others who use the space through engagement with business initiated or co-created communities within the coffee shop walls.

Through exploring the activities of coffee shops in England this research has demonstrated that coffee shops have the potential to play important social roles in local communities acting as spaces where people can gather and interact. This research revealed how coffee shops have the potential to be used in a myriad of ways where people can gather, put aside the concerns of work and home, contributing to a community's social vitality with others who use the space, and in doing so coffee shops have the potential to act as 'spaces of community' in the urban consumptionscape.

These communities however, are not simply 'place-based' are 'interest-based', and additional research is needed to consider the impact of this shift on local areas in which they are embedded. From an industry perspective there needs to be further consideration of the implications of the developments discussed in this paper, and to consider what extent social engagement might be an important part of their business model, and how the ways this might take place in different types of coffee shops, and the nature of how these activities are instigate and maintained. Further research is also needed to consider the extent to which these communities contribute to the development of social capital in urban spaces, how they fit into the modern notion of the neighbourhood, the dynamics of these coffee shops and their communities, and how they are perceived by local residents to consider the broader role of coffee shops in urban spaces and how they can advance our understanding of community.

## CRediT authorship contribution statement

**Jennifer Ferreira:** Funding acquisition, Project administration, Conceptualization, Methodology, Investigation, Writing - original draft. **Carlos Ferreira:** Investigation, Writing - original draft. **Elizabeth Bos:** Investigation, Writing - original draft.

## Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.geoforum.2020.12.024.

## References

Strategies, Allegra, 2019. Project Café UK, 2019. Allegra Strategies, London.
Strategies, Allegra, 2015. The Future of Coffee. Allegra Strategies, London.
Ardekani, R., Rath, J., 2017. Coffee people in Tehran, Glasgow and Amsterdam. J. Consum. Cult. 20 (1), 122–140.
Beck, U., Beck-Gernsheim, E., 2002. Individualization. Sage, London.
Blokland, T., 2017. Community as Urban Practice. Polity Press, Cambridge.
British Beer and Pub Association, 2018. Statistical Handbook 2018. British Beer and Pub Association.
Broadway, M., Legg, R., Broadway, J., 2017. Coffeehouses and the art of social engagement: an analysis of Portland Coffeehouses. Geogr. Rev., DOI: 10.1111/gere.12253.
Brown, J., 2017. Curating the "third place"? coworking and the mediation of creativity. Geoforum 82 (1), 112–126.
Brown, K., 2013. Buying into Fair Trade: Culture, Morality and Consumption. New York University Press, New York.
Coffee #1 (2017) Coffee #1 Locations [online] available from <https://www.coffee1.co.uk/locations/>.
Cowan, B., 2005. The Social Life of Coffee: The Emergence of the British Coffee House. Yale University Press, New Haven.
DCLG, 2013. High Street Renewal Fund. Department for Communities and Local Government, London.
Felton, E., 2019. Coffee, the café and the 21st century. Routledge, Abingdon.
Ferreira, J., 2016. Cafe Nation? Exploring the Growth of the UK Cafe Industry. Area 49 (1), 69–76.
Ferreira, J., 2015. 'How the Third Wave of Coffee Shops Is Transforming High Streets'. The Conversation [online] 27 July. available from <https://theconversation.com/how-the-third-wave-of-coffee-shops-is-transforming-high-streets-45118>.
Frederick, W., 1998. Creatures, corporations, communities, chaos, complexity: naturological view of the corporate social role. Bus. Soc. 37 (4), 358–389.
Goffman, E., 1963. Behaviour in Public Places. The Free Press, New York.
Granovetter, M., 1973. The strength of weak ties. Am. J. Sociol. 6 (2), 1360–1380.
Greenhalgh, T., Jackson, C., Shaw, S., Janamian, T., 2016. Achieving research impact through co-creation in community base health services: literature review and case study. The Millbank Quart. 94 (2), 392–429.
Habermas, J., 1989. The Structural Transformation of the Public Sphere. MIT Press, Cambridge, MA.
Hall, S., 2012. City, Street and Citizen: The Measure of the Ordinary. Routledge, London.
Harvey, C., Autumn-Hall, L., 2015. Measuring urban streetscape for liveability: a review of approaches. The Professional Geographer 1–10.

Henriksen, I.M., Tjora, A., 2014. Interaction pretext: Experiences of community in the urban neighbourhood. Urban Studies 51 (10), 2111–2124.
Henriksen, I., Skjølsvold, T., Grønning, I., 2013. The café community. In: Tjora, A., Scambler, G. (Eds.), Café Society. Palgrave Macmillan, London, pp. 87–102.
Hubbard, P., 2017. Enthusiasm, craft and authenticity on the High Street: micropubs as 'community fixers'. Social & Cultural Geography. https://doi.org/10.1080/14649365.2017.1380221.
Hyra, D., 2017. Race, Class and Politics in the Cappuccino City. University of Chicago Press, Chicago.
Jacobs, J., 1961. The Death and Life of Great American Cities. Random House, New York.
Jeffrey, A., Staeheli, L.A., Buire, C., Čelebičić, V., 2017. Drinking coffee, rehearsing civility, making subjects. Political Geography. https://doi.org/10.1016/j.polgeo.2017.09.013.
Jones, H., Neal, S., Mohan, G., Connell, K., Cochrane, A., Bennett, K., 2015. 'Urban multiculture and everyday encounters in semi-public franchised cafe spaces'. Sociol. Rev. 1–18.
Khomami, N., Halliday, J., 2015. 'Shoreditch Cereal Killer Cafe Targeted in Anti-Gentrification Protests'. The Guardian [online] 27 September. available from <http://www.theguardian.com/uk-news/2015/sep/27/shoreditch-cereal-cafe-targeted-by-anti-gentrification-protesters> [30 November 2017].
Laurier, E., Philo, C., 2006a. Possible geographies: a passing encounter in a cafe. Area 38, 353–363.
Laurier, E., Philo, C., 2006b. Cold shoulders and napkins handed: gesture of responsibility. Trans. Inst. Brit. Geogr. 31, 193–207.
Laurier, E., Philo, C., 2007. 'A parcel of muddling muckworms': revisiting Habermas and the English coffee-houses. Soc. Cult. Geogr. 8 (2), 259–281.
Lin, E., 2012. Starbucks as a third place: glimpses into Taiwan's consumer culture and lifestyles. J. Int. Consum. Market. 24, 119–128.
Mehta, R., Zhu, R., Cheema, A., 2012. Is noise always bad? Exploring the effects of ambient noise on creative cognition. J. Consum. Res. 39 (4), 784–799.
Montgomery, J., 1997. Café culture and the city: the role of pavement cafes in urban public social life. J. Urb. Des. 2 (1), 83–102.
Morris, J., 2019. Coffee: a global history. Reaktion Books, London.
O'Brien, G., 2017. Small and slow is beautiful: well-being, 'socially connective retail' and the independent bookshop. Soc. Cult. Geogr. 18 (4), 573–595.
Oldenburg, R., 2013. The Cafe as a Third Place. In: Cafe Society. Palgrave Macmillan, London, pp. 7–21.
Oldenburg, R., 1999. The Great Good Place: Cafes, Coffee Shops, Bookstores, Bars, Hair Salons, and Other Hangouts at the Heart of a Community. 3rd Revised edition edition. New York : Berkeley, Calif.: Marlowe & Co.
Orford, J., Rolfe, A., Dalton, S., Painter, C., Webb, H., 2009. Pub and community: the views of Birmingham untreated heavy drinkers. J. Commun. Appl. Soc. Psychol. 19 (1), 68–82.
Putnam, R., 2000. Bowling Alone: The Collapse and Revival of American Community. Simon and Schuster, New York.
Ramaswamy, V., Ozcan, K., 2014. The Co-creation Paradigm. Stanford University Press, Redwood City, CA.
Sandiford, P.J., Divers, P., 2014. The english public house as a 21st century socially responsible community institution. Int. J. Hospital. Manage. 41 (Supplement C), 88–96.
SCA, 2017. The 2017 Western European Coffee Market Size Report [online] available from <http://www.scanews.coffee/2017/11/29/2017-western-european-coffee-market-size-report/>.
Scambler, G., 2013. Cafes, Third Places, and the Enabing Sector of Civil Society. In: Cafe Society. Palgrave Macmillan, New York, pp. 67–86.
Shapira, R., Navon, D., 1991. Alone together: public and private dimensions of a Tel-Aviv Cafe. Qualitative Sociology 14 (2), 107–125.
Simon, B., 2009. Everything But the Coffee: Learning about America from Starbucks. University of California Press, Berkeley.
Skrbis, Z., Woodward, I., 2007. The ambivalence of ordinary cosmopolitanism: investigating the limits of cosmopolitan openness. The Sociological Review 55 (4), 730–747.
Slater, T., 2010. Missing Marcuse: on gentrification. City 13 (2–3), 292–311.
Smith, M., 1996. The empire filters back: consumption, production, and the politics of starbucks coffee. Urban Geography 17 (6), 505–525.
Stenseth, B., 2013. Heart of Urbanism. The Cafe: A Chapter of Cultural History. In: Cafe Society. Palgrave Macmillan, London, pp. 23–42.
Thomas, M., 2006. Girls, consumption space and the contradictions of hanging out in the city. Soc. Cult. Geogr. 6 (4), 587–605.
Tjora, A., 2013. Communal Awareness in the Urban Cafe. In: Cafe Society. Palgrave Macmillan, New York, pp. 103–126.
Tjora, A., Scambler, P.G. (eds.), 2013. Café Society. New York, New York: Palgrave Macmillan.
Tönnies, F., 1957. Community and Society: Gemeinschaft und Gesellschaft, by Ferdinand Tönnies . Translated and edited by Charles P. Loomis. Michigan State University Press, East Lansing, Michigan.
Turkle, S., 2015. Reclaiming Conversation: The Power of Talk in a Digital Age. Penguin Books, New York.
Urry, J., 2007. Mobilities. Polity Press, Cambridge.
Valentine, G., 2008. Living with difference: reflections on geographies of encounter. Prog. Hum. Geogr. 32, 323–337.
Van Wynsberghe, R., Ronaye, M., 1999. 'Leisure as the Basis for Community: Cohousing, Sustainability and Diversity'. International Journal of Urban Labour and Leisure [online] 1 (1). available from <http://www.ijull.co.uk/vol1/1/00004.htm>.
Warner, J., Talbot, D., Bennison, G., 2012. The café as affective community space: reconceptualizing care and emotional labour in every day life. Crit. Soc. Pol. 33 (2), 305–324.
Woldoff, R., Lozzi, D., Dilks, L., 2013. The social transformation of coffee houses: the emergence of chain establishments and the private nature of usage. Int. J. Soc. Sci. Stud. 1, 205–218.
Wrigley, N., Lambiri, D., 2015. British High Streets: From Crisis to Recovery? A Comprehensive Review of the Evidence [online] Southampton: Economic and Social Research Council. available from <http://thegreatbritishhighstreet.co.uk/pdf/GBHS-British-High-Streets-Crisis-to-Recovery.pdf>.
Zukin, S., 2010. Naked City: The Death and Life of Authentic Urban Places. Oxford University Press, Oxford.
Zwass, V., 2010. Co-creation: toward a taxonomy and an integrated research perspective. Int. J. Electron. Commerce 15 (1), 13–48.

 

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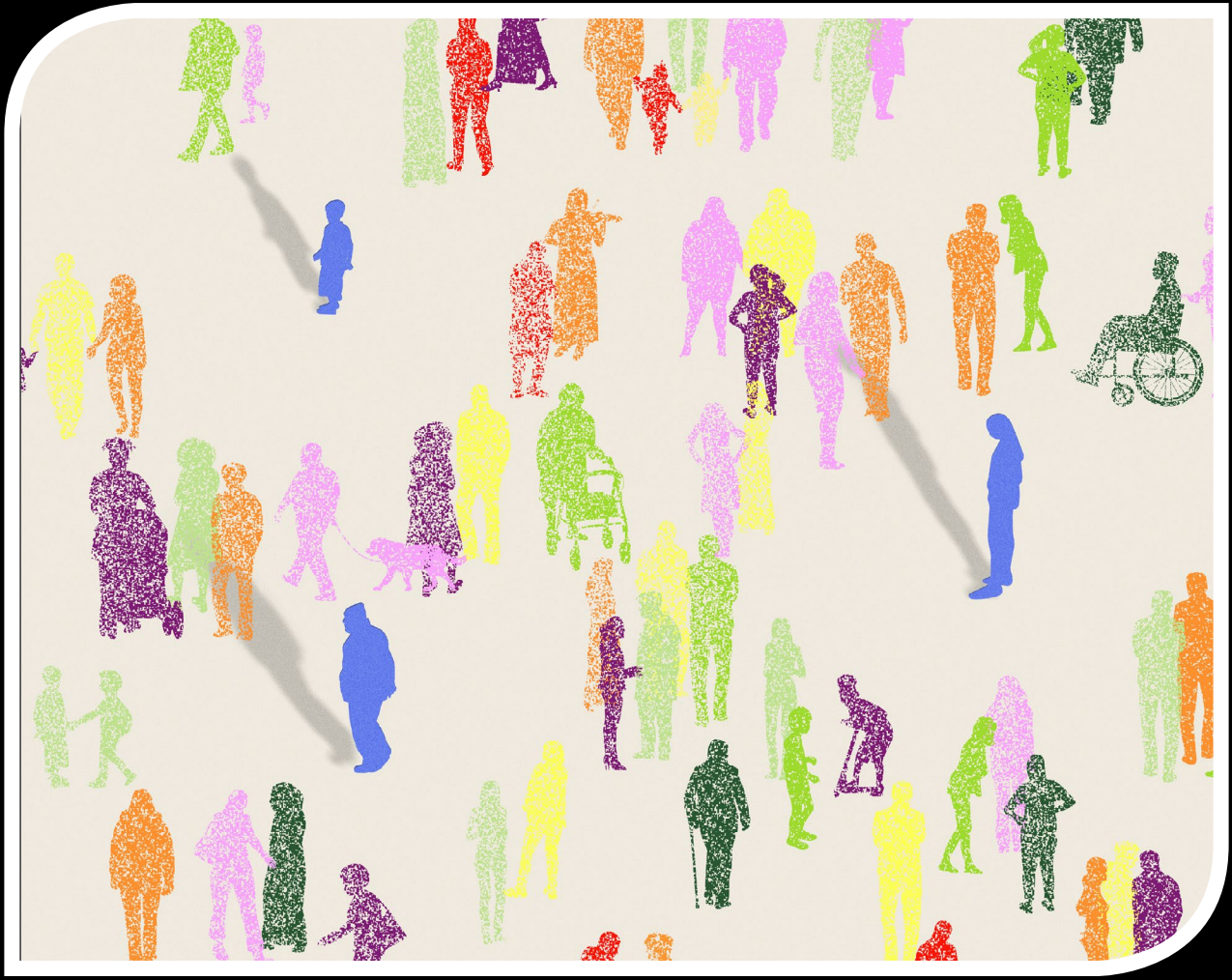
# Our Epidemic of Loneliness and Isolation 2023

## The U.S. Surgeon General's Advisory on the Healing Effects of Social Connection and Community



Chapter 2

# How Social Connection Impacts Individual Health and Well-Being

Extensive scientific findings from a variety of disciplines, including epidemiology, neuroscience, medicine, psychology, and sociology, converge on the same conclusion: social connection is a significant predictor of longevity and better physical, cognitive, and mental health, while social isolation and loneliness are significant predictors of premature death and poor health.[10,20,32,124] In fact, the benefits of social connection extend beyond health-related outcomes. They influence an individual's educational attainment, workplace satisfaction, economic prosperity, and overall feelings of well-being and life fulfillment. This chapter summarizes the rapidly growing body of evidence on the relationship between various indicators of social connection and these outcomes for individuals.



## Individual Health Outcomes

### Survival and Mortality

> "Over four decades of research has produced robust evidence that lacking social connection — and in particular, scoring high on measures of social isolation — is associated with a significantly increased risk for early death from all causes."[10]
>
> 2020 Consensus Study Report,
> National Academies of Sciences Engineering and Medicine

Evidence across scientific disciplines converges on the conclusion that socially connected people live longer. Large population studies have documented that, among initially healthy people tracked over time, those who are more socially connected live longer, while those who experience social deficits, including isolation, loneliness, and poor-quality relationships, are more likely to die earlier, regardless of the cause of death.[37,125-128] Systematic research demonstrating the link between social connection and mortality risk dates to one of the first large-scale longitudinal epidemiological studies conducted in 1979.[129] This research found that people who lacked social connection were more than twice as likely than those with greater social connection to die within the follow-up period, even after accounting for age, health status, socioeconomic status, and health practices.[129]

**KEY DATA**

**50%**

Data across 148 studies, with an average of 7.5 years of follow-up, suggest that social connection increases the odds of survival by 50%.

More recent estimates, based on synthesizing data across 148 studies, with an average of 7.5 years of follow-up, suggest that social connection increases the odds of survival by 50%.[128] Indeed, the effects of social connection, isolation, and loneliness on mortality are comparable, and in some cases greater, than those of many other risk factors (see **Figure 4**) including lifestyle factors (e.g., smoking, alcohol consumption, physical inactivity), traditional clinical risks factors (e.g., high blood pressure, body mass index, cholesterol levels), environmental factors (e.g., air pollution), and clinical interventions (e.g., flu vaccine, high blood pressure medication, rehabilitation).[128,130]



CHAPTER 2: INDIVIDUAL HEALTH

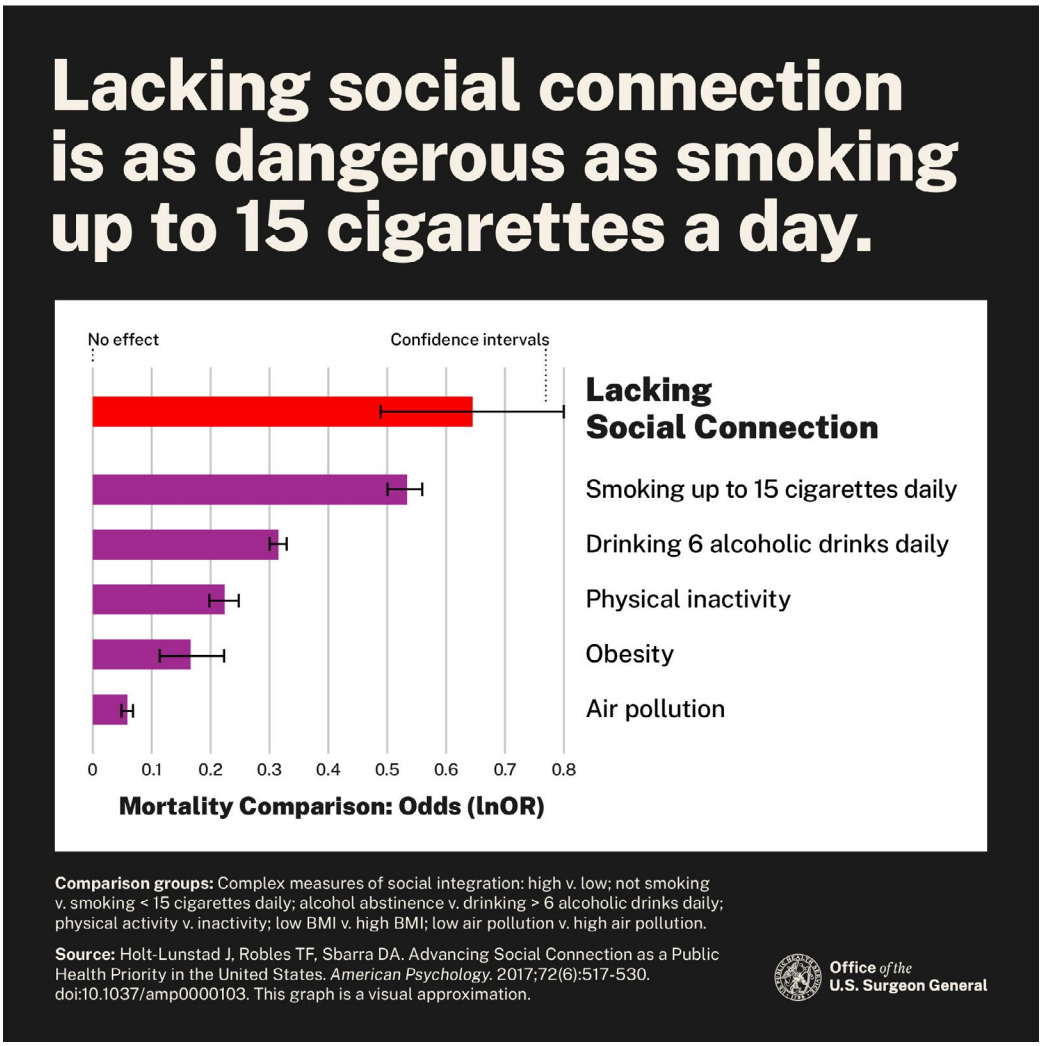



**FIGURE 4:** Lacking social connection is as dangerous as smoking up to 15 cigarettes a day.

Over the years, the number of studies, the rigor of their methods, and the size of the samples have all increased substantially, providing stronger confidence in this evidence. These replicate the finding that social connection decreases the risk of premature death.

Taken together, this research establishes that the lack of social connection is an independent risk factor for deaths from all causes, including deaths caused by diseases.[131]



## Cardiovascular Disease

**KEY DATA**

A synthesis of data across 16 independent longitudinal studies shows poor social relationships (social isolation, poor social support, loneliness) were associated with a 29% increase in the risk of heart disease and a 32% increase in the risk of stroke.

The evidence linking social connection to physical health is strongest in heart disease and stroke outcomes.[10,58] Dozens of studies have found that social isolation and loneliness significantly increase the risk of morbidities from these conditions.[10,132,133] Among this evidence, a synthesis of data across 16 independent longitudinal studies shows poor social relationships (social isolation, poor social support, loneliness) were associated with a 29% increase in the risk of heart disease and a 32% increase in the risk of stroke.[38] Interestingly, these effects can begin early in life and stretch over a lifetime. Research has also found that childhood social isolation is associated with increased cardiovascular risk factors such as obesity, high blood pressure, and blood glucose levels in adulthood.[133-135] Further, in a 2022 statement, the American Heart Association concluded that "social isolation and loneliness are common, yet underrecognized, determinants of cardiovascular health and brain health."[133]

Heart failure patients who reported high levels of loneliness had a 68% increased risk of hospitalization, a 57% higher risk of emergency department visits, and a 26% increased risk of outpatient visits, compared with patients reporting low levels of loneliness.[136] Combining data from 13 studies on heart failure patients, researchers found that poor social connection is associated with a 55% greater risk of hospital readmission.[137] This was consistent across both objective and perceived social isolation, including living alone, lack of social support, and poor social network. Furthermore, evidence suggests that people who are less socially connected, particularly those living alone, may be less likely to make it to the hospital, increasing their risk of dying from a cardiac event.[138] Conversely, a heart attack is less likely to be fatal for people living with others or who have more social contacts, perhaps because of the immediate response and availability of help during the event.[138]

## Hypertension

High blood pressure (hypertension) is one of the leading causes of cardiovascular disease.[139] Several studies demonstrate that the more social support one has, the greater the reduction in the possibility of developing high blood pressure, even in populations who are at higher risk for the condition, such as Black Americans. Greater social support in this group is associated with a 36% lower risk of high blood pressure in the long-term.[140] Among older adults, the effect of social isolation on hypertension risk is even greater than that of other major clinical risk factors such as diabetes.[59]



Since high blood pressure most often doesn't have symptoms, it is possible for people to be unaware of even severe underlying cases.[141] The disorder may remain undiagnosed for years, which can elevate the risk for a wide range of physiological complications.[141] However, among older adults, people with higher perceived emotional support from family and friends, and with frequent exposure to health-related information within their social networks, are significantly less likely to have undiagnosed and uncontrolled hypertension.[142]

The results of many research studies also reflect a strong correlation between social connection and high blood pressure control. Regular participation in two or more social or community-based groups[143]; emotional and informational support from family, friends, professional contacts, community organizations, and peer groups[144-146]; and frequent network interactions[142] may improve hypertension management, including following treatment recommendations and long-term lifestyle adjustments. Findings from the National Social Life, Health, and Aging Project (NSHAP) suggest a "causal role of social connections in reducing hypertension," particularly in adults over the age of 50.[59]

## Diabetes

Evidence gathered over the last 25 years has demonstrated that social context is important to the development and management of diabetes.[147] Population-based studies show the impact of social connection on the development of type 2 diabetes and diabetic complications.[148,149] For example, social disconnection (poor structural social support[150] and living alone[151] in men, low emotional support in women,[152] and not having a current partner in women older than 70[153]) has been linked to an increased risk for the development of type 2 diabetes. Furthermore, living alone increased the risk of developing type 2 diabetes among women with impaired glucose tolerance.[154]

**KEY DATA**

The involvement and support of family members has been repeatedly shown to improve disease management and the health of people with type 1 diabetes and type 2 diabetes.

By contrast, social connection has been associated with better self-rated health and disease management among individuals with diabetes.[155-157] The involvement and support of family members has also been repeatedly shown to improve disease management and the health of people with type 1 diabetes and type 2 diabetes.[147] Whereas, smaller social network size has been associated with newly diagnosed type 2 diabetes and complications from diabetes.[148,149] These associations between social connection and broader diabetic outcomes including diagnosed pre-diabetes and type 2 diabetes, macrovascular complications (e.g., heart attack, stroke) and microvascular complications (e.g., diabetic retinopathy, impaired sensitivity in the feet, and signs of kidney disease) were independent of blood sugar (glucose) control, quality of life, and other cardiac risk factors.[148,149]



What explains this phenomenon? Diabetic outcomes may be better among people who are more socially connected due to better diabetic management behaviors and patient self-care such as medication adherence, physical activity, diet, and foot care. For example, in a meta-analysis of 28 studies, social support from family and friends was significantly associated with better self-care, particularly blood sugar monitoring.[158] Finally, evidence from the National Health and Nutrition Examination Survey found that among older adults with diabetes, those with a large social support network size (at least six close friends) had a reduced risk of all-cause mortality.[159]

### Infectious Diseases

People who are less socially connected may have increased susceptibility and weaker immune responses when they are exposed to infectious diseases. In a series of studies examining factors that contribute to illness after exposure to viruses like the common cold and flu, loneliness and poor social support were found to significantly contribute to the development and severity of the illnesses.[42,160] In one study where participants were exposed to a common cold virus, individuals with social ties to six or more diverse social roles (e.g., parent, spouse, friend, family, co-worker, group membership) had a four-fold lower risk of developing a cold when compared to people who had ties to fewer (1-3) diverse social roles.[161] These effects cannot be explained by previous exposure, since those who are more socially connected have stronger immune responses independent of baseline antibody count—suggesting stronger immune responses even when exposed to new viruses.[42] A study conducted on immune responses to the COVID-19 vaccine found that a lack of social connection with neighbors and resultant loneliness was associated with weaker antibody responses to the vaccine.[162]

KEY DATA

**50%**

Chronic loneliness and social isolation can increase the risk of developing dementia by approximately 50% in older adults.

### Cognitive Function

Substantial evidence also links social isolation and loneliness with accelerated cognitive decline and an increased risk of dementia in older adults,[10,41] including Alzheimer's disease.[163] Chronic loneliness and social isolation can increase the risk of developing dementia by approximately 50% in older adults, even after controlling for demographics and health status.[41] A study that followed older adults over 12 years found that cognitive abilities declined 20% faster among those who reported loneliness.[164]



When taken together, this evidence consistently shows that wider social networks and more frequent social engagements with friends and family are associated with better cognitive function and may protect against the risk of dementia.[40,165] This suggests that investments in social connection may be an important public health response to cognitive decline.

### Depression and Anxiety

KEY DATA

Loneliness and social isolation among children and adolescents increase the risk of depression and anxiety.

Depression and anxiety are often characterized by social withdrawal, which increases the risk for both social isolation and loneliness; however, social isolation and loneliness also predict increased risk for developing depression and anxiety and can worsen these conditions over time. A systematic review of multiple longitudinal studies found that the odds of developing depression in adults is more than double among people who report feeling lonely often, compared to those who rarely or never feel lonely.[39] Furthermore, in older adults, both social isolation and loneliness have been shown to independently increase the likelihood of depression or anxiety.[166] These findings are also consistent among younger people. A review of 63 studies concluded that loneliness and social isolation among children and adolescents increase the risk of depression and anxiety, and that this risk remained high even up to nine years later.[167]

Importantly, social connection also seems to protect against depression even in people with a higher probability of developing the condition. For example, frequently confiding in others is associated with up to 15% reduced odds of developing depression among people who are already at higher risk due to their history of traumatic or otherwise adverse life experiences.[168]

...

## Social Connection Influences Health Through Multiple Pathways

While the effects of social connection on health are clear, research also helps explain how our level of social connection ultimately results in better or worse health. A key part of the explanation involves understanding how social connection influences behavioral, biological, and psychological processes, which in turn influence health outcomes. A large body of evidence has identified several plausible pathways (see **Figure 5**).[59,176-180]



CHAPTER 2: INDIVIDUAL HEALTH

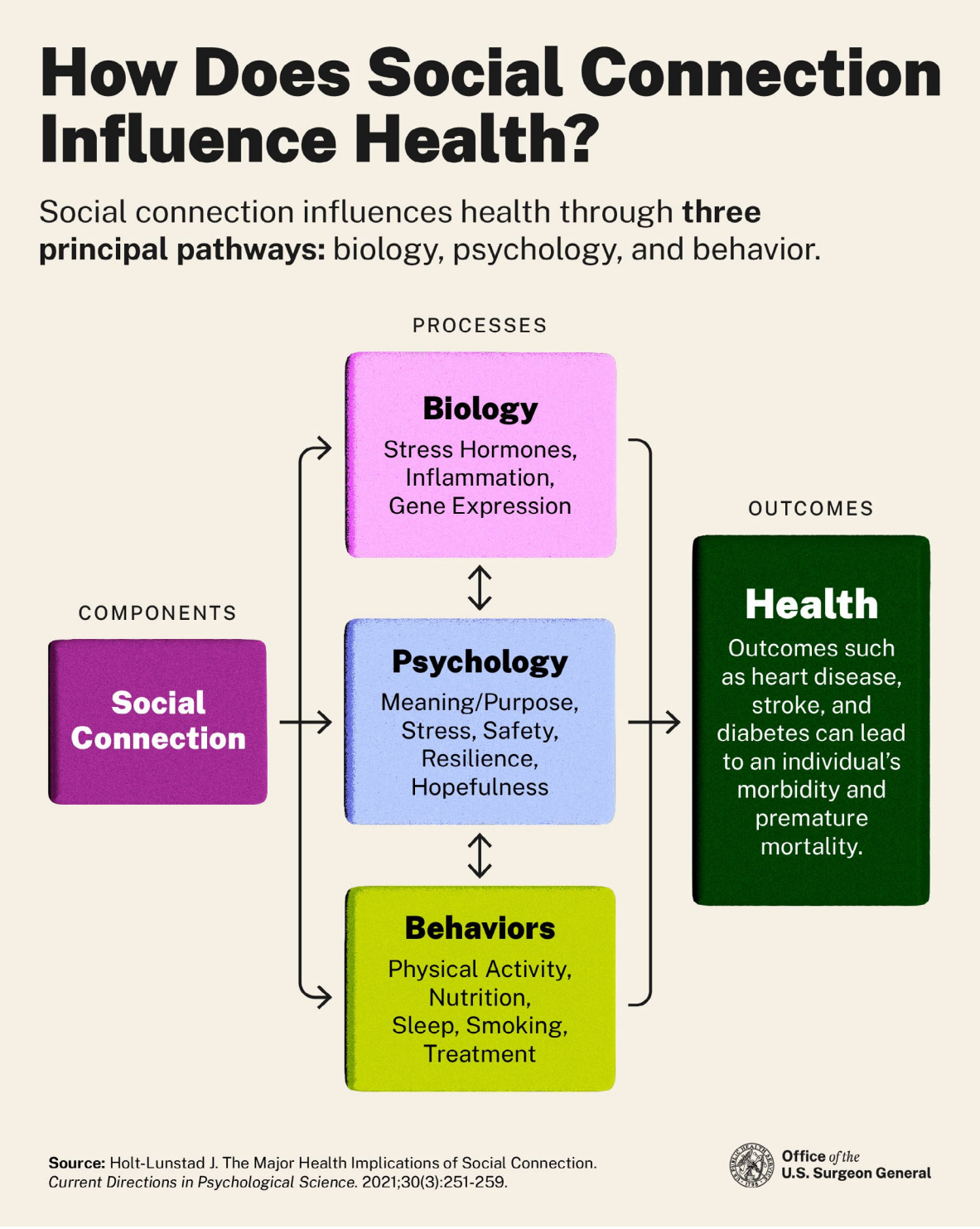



**FIGURE 5:** How Does Social Connection Influence Health?



### Social Connection Influences Biological Processes

The role of social connection on biology emerges early in life and continues across the life course, contributing to risk and protection from disease.[59] Several reviews document that social connection can influence health through specific biological pathways, including cardiovascular and neuroendocrine dysregulation,[181] immunity,[42,177,182-184] and gut-microbiome interactions.[185,186] Because regulation of these systems is critical for good health, the documented influence between social connection and these biological pathways likely explains the impact on the risk of the development of disease.

Biological systems often do not operate independently. This means that increases in blood pressure, circulating stress hormones, and inflammation may occur simultaneously, potentially compounding risk across several biological systems.[187]

One biological pathway of great interest is inflammation, given that it has been implicated as a factor in many chronic illnesses.[188] Evidence shows that being objectively isolated, or even the perception of isolation, can increase inflammation to the same degree as physical inactivity.[59] Similarly, lower social support is associated with higher inflammation.[189,190] Chronic inflammation throughout the body has been linked to various chronic illnesses across the lifespan, such as cardiovascular disease, cancer, diabetes, depression, and Alzheimer's disease, as well as a variety of mental, cognitive, and physical health outcomes[188,191] that increase the risk of premature mortality. Thus, inflammation may be a common pathway that explains the many diverse health outcomes associated with isolation and loneliness.

The protective, or positive, effects of social connection may operate on biological systems in a similar way, meaning that social connection may reduce the risk of disease by reducing biological system dysregulation. For example, increased levels of social connection can improve various biomarkers of cardiovascular functioning, including blood pressure,[192] cardiovascular reactivity,[193] and oxidative stress.[194] In addition, social support and social bonding are associated with better regulation of the neuroendocrine system, including the role of oxytocin in both early life and adult attachment.[181,195-197]



## Social Connection Influences Psychological Processes

**KEY DATA**

Adults across the globe rate their social relationships, particularly with family and close friends, as the most important source of meaning, purpose, and motivation in their lives.

Social connection can also influence health through psychological processes, such as the sense of meaning and purpose. Adults across the globe rate their social relationships, particularly with family and close friends, as the most important source of meaning, purpose, and motivation in their lives.[198] A sense of meaning positively contributes to health because it motivates greater self-regulation in pursuing goals — including health goals.[180] Furthermore, evidence suggests that individuals with higher purpose and perceived emotional and practical support from their social networks are more likely to engage in health-promoting behaviors, such as the use of preventive health care services.[199,200]

Other psychological processes, including the perception of stress, may also have implications for health because they can influence our biology and behavior. For example, higher social connection provides increased opportunities for and access to support, thus reducing the likelihood of perceiving challenging situations as stressful and helping us cope with stressful situations to minimize their impact.[28,201] Conversely, being isolated or in poor quality relationships can increase the likelihood that one perceives potential challenges as stressful. This stress may be heightened because the individual has less support and fewer resources to draw upon to cope with the situation.[28,201]

Though certain forms of manageable, short-term challenges can boost performance and motivation in day-to-day life, chronic stress and cumulative biologic burden can contribute to worsened health outcomes. For example, stress can contribute to poorer health-related behaviors, cause disruptions in brain development, and increase the risk for mental health conditions and other health problems such as obesity, heart disease, and diabetes.[202-205] Additionally, while loneliness, poor-quality relationships, and social negativity can aggravate stress responses and influence long-term health outcomes,[206] being more socially connected can buffer against maladaptive stress responses and the negative health effects of stress.[28,201]

A sense of meaning positively contributes to health because it motivates greater self-regulation in pursuing goals — including health goals.



### Social Connection Influences Behaviors

Social connection is also significantly associated with a number of health-related behaviors, including lifestyle behaviors (e.g., diet, exercise, sleep),[207-210] and treatment adherence (e.g., taking medication as directed, engaging in recommended prevention measures)[144,199,211,212] which ultimately influence our health and longevity. Social influence can be direct-loved ones encouraging one to get more sleep or reminding one to take their medication — or subtle, through social norms that communicate approval or disapproval of certain behaviors (like … smoking, exercise). In fact, evidence shows people are far more likely to be physically active if their peers and friends also exercise,[213,214] and they are more likely to stop smoking themselves if their social contacts do so as well.[215] However, they are also less likely to stop smoking if they are in close connection to others who smoke, or even at risk for relapse if they had successfully quit smoking previously.[216,217] Thus, it is clear that it is not just the presence of social connection and social support but the nature of the behaviors and norms in one's social network that influence health-related behaviors.

## Individual Educational and Economic Benefits

The benefits of social connection extend beyond the well-being of individuals' health to quality of life, education, employment, and economic outcomes. Just as with health, those who lack sufficient social connection, whether because they are isolated, lonely, or in poor-quality relationships, seem to be at higher risk for poorer outcomes in these aspects of life as well.

### Educational Benefits

Research shows that children and adolescents who enjoy positive relationships with their peers, parents, and teachers experience improved academic outcomes. For example, a review of youth mentoring programs found a positive association between mentoring programs intended to promote positive youth outcomes and improved school attendance, grades, and academic achievement test scores.[218] Further, school and family connectedness during adolescent years may predict subsequent positive outcomes in early adulthood, including a higher likelihood of graduating college and attaining a 4-year college degree.[219]

In contrast, the lack of quality social connections inhibits student progression even in higher education settings. For example, among medical students, feeling socially isolated is associated with dropping out.[45] The lack of social connection is cited as a prime reason for leaving a program.



### Economic Benefits

Supportive and inclusive relationships at work are associated with employee job satisfaction, creativity, competence, and better job performance.[220-224] Quality social support, social integration, and regular communication among co-workers of all levels are key in preventing chronic work stress and workplace burnout.[48,225] These resources may even be linked to shorter recovery times and less missed work after work-related injuries or illnesses.[225,226] Workplace connectedness is also associated with enhanced individual innovation, engagement, and quality of work, all of which can influence career advancements, income, and overall economic stability.[220,223]

Social connection outside the workplace also plays an important role in an individual's economic situation. Diverse social networks that facilitate interaction and relationship-building among people of differing socioeconomic status (SES) may provide opportunities for individuals from lower SES backgrounds to gain stronger footing in the labor market and obtain higher-paying jobs.[227,228] Such bridging, cross-class ties are among the most important predictors of upward economic mobility.

Additionally, activities that better connect individuals to one another, including immersion in local community-based activities or volunteering, can also equip individuals with desirable skills that make them more employable, and significantly increase the likelihood of unemployed individuals becoming employed.[229-231]



# References


**10.** National Academies of Sciences Engineering and Medicine (NASEM). *Social Isolation and Loneliness in Older Adults: Opportunities for the Health Care System.* Washington, DC: The National Academies Press; 2020.

**20.** Holt-Lunstad J. Why Social Relationships Are Important for Physical Health: A Systems Approach to Understanding and Modifying Risk and Protection. *Annu Rev Psychol.* 2018;69:437-458.

**28.** Cohen S, Wills TA. Stress, social support, and the buffering hypothesis. *Psychological Bulletin.* 1985;98:310-357.

**32.** Holt-Lunstad J. Social Connection as a Public Health Issue: The Evidence and a Systemic Framework for Prioritizing the "Social" in Social Determinants of Health. *Annual Review of Public Health.* 2022;43(1):193-213.

**37.** Holt-Lunstad J, Smith TB, Baker M, Harris T, Stephenson D. Loneliness and social isolation as risk factors for mortality: a meta-analytic review. *Perspect Psychol Sci.* 2015;10(2):227-237.

**38.** Valtorta NK, Kanaan M, Gilbody S, Ronzi S, Hanratty B. Loneliness and social isolation as risk factors for coronary heart disease and stroke: systematic review and meta-analysis of longitudinal observational studies. *Heart.* 2016;102(13):1009-1016.

**39.** Mann F, Wang J, Pearce E, et al. Loneliness and the onset of new mental health problems in the general population. *Soc Psychiatry Psychiatr Epidemiol.* 2022;57(11):2161-2178.

**40.** Penninkilampi R, Casey AN, Singh MF, Brodaty H. The Association between Social Engagement, Loneliness, and Risk of Dementia: A Systematic Review and Meta-Analysis. *J Alzheimers Dis.* 2018;66(4):1619-1633.

**41.** Lazzari C, Rabottini M. COVID-19, loneliness, social isolation and risk of dementia in older people: a systematic review and meta-analysis of the relevant literature. *Int J Psychiatry Clin Pract.* 2021:1-12.

**42.** Cohen S. Psychosocial Vulnerabilities to Upper Respiratory Infectious Illness: Implications for Susceptibility to Coronavirus Disease 2019 (COVID-19). *Perspect Psychol Sci.* 2020:1745691620942516.

**45.** Maher BM, Hynes H, Sweeney C, et al. Medical School Attrition-Beyond the Statistics A Ten Year Retrospective Study. *BMC Medical Education.* 2013;13(1):13.

**48.** United States Department of Health and Human Services. *The U.S. Surgeon General's Framework for Workplace Mental Health and Well-being.* Washington, D.C.: U.S. Department of Health and Human Services, Office of the U.S. Surgeon General; 2022.

**58.** Holt-Lunstad J. The Major Health Implications of Social Connection. *Current Directions in Psychological Science.* 2021;30(3):251-259.

**59.** Yang YC, Boen C, Gerken K, Li T, Schorpp K, Harris KM. Social relationships and physiological determinants of longevity across the human life span. *Proc Natl Acad Sci U S A.* 2016;113(3):578-583.

**124.** Leigh-Hunt N, Bagguley D, Bash K, et al. An overview of systematic reviews on the public health consequences of social isolation and loneliness. *Public Health.* 2017;152:157-171.

**125.** Shor E, Roelfs DJ. Social contact frequency and all-cause mortality: a meta-analysis and meta-regression. *Social Science & Medicine.* 2015;128:76-86.

**126.** Pinquart M, Duberstein PR. Associations of social networks with cancer mortality: a meta-analysis. *Crit Rev Oncol Hematol.* 2010;75(2):122-137.

**127.** Rico-Uribe LA, Caballero FF, Martin-Maria N, Cabello M, Ayuso-Mateos JL, Miret M. Association of loneliness with all-cause mortality: A meta-analysis. *PLoS One.* 2018;13(1):e0190033.

**128.** Holt-Lunstad J, Smith TB, Layton JB. Social relationships and mortality risk: a meta-analytic review. *PLoS Med.* 2010;7(7):e1000316.

**129.** Berkman LF, Syme SL. Social networks, host resistance, and mortality: a nine-year follow-up study of Alameda County residents. *Am J Epidemiol.* 1979;109(2):186-204.

**130.** Pantell M, Rehkopf D, Jutte D, Syme SL, Balmes J, Adler N. Social isolation: a predictor of mortality comparable to traditional clinical risk factors. *Am J Public Health.* 2013;103(11):2056-2062.

**131.** Howick J, Kelly P, Kelly M. Establishing a causal link between social relationships and health using the Bradford Hill Guidelines. *SSM Popul Health.* 2019;8:100402.

**132.** Czajkowski SM, Arteaga SS, Burg MM. Social support and cardiovascular disease. In: *Handbook of Cardiovascular Behavioral Medicine*. Springer; 2022:605-630.

**133.** Cené CW, Beckie TM, Sims M, et al. Effects of Objective and Perceived Social Isolation on Cardiovascular and Brain Health: A Scientific Statement From the American Heart Association. *Journal of the American Heart Association.* 2022;11(16):e026493.

**134.** Caspi A, Harrington H, Moffitt TE, Milne BJ, Poulton R. Socially Isolated Children 20 Years Later: Risk of Cardiovascular Disease. *Archives of Pediatrics & Adolescent Medicine.* 2006;160(8):805-811.

**135.** Danese A, Moffitt TE, Harrington H, et al. Adverse childhood experiences and adult risk factors for age-related disease: depression, inflammation, and clustering of metabolic risk markers. *Arch Pediatr Adolesc Med.* 2009;163(12):1135-1143.

**136.** Manemann SM, Chamberlain AM, Roger VL, et al. Perceived Social Isolation and Outcomes in Patients With Heart Failure. *J Am Heart Assoc.* 2018;7(11).

**137.** Gorji MH, Fatahian A, Farsavian A. The impact of perceived and objective social isolation on hospital readmission in patients with heart failure: a systematic review and meta-analysis of observational studies. *General Hospital Psychiatry.* 2019;60:27-36.

**138.** Smith RW, Barnes I, Green J, Reeves GK, Beral V, Floud S. Social isolation and risk of heart disease and stroke: analysis



## REFERENCES

of two large UK prospective studies. *Lancet Public Health.* 2021;6(4):e232-e239.

**139.** National Center for Chronic Disease Prevention and Health Promotion. Heart Disease and Stroke. Centers for Disease Control and Prevention,. https://www.cdc.gov/chronicdisease/resources/publications/factsheets/heart-disease-stroke.htm. Published 2022. Accessed April 2023.

**140.** Harding BN, Hawley CN, Kalinowski J, et al. Relationship between social support and incident hypertension in the Jackson Heart Study: a cohort study. *BMJ Open.* 2022;12(3):e054812.

**141.** National Center for Chronic Disease Prevention and Health Promotion, Division for Heart Disease and Stroke Prevention. High Blood Pressure Symptoms and Causes. Centers for Disease Control and Prevention https://www.cdc.gov/bloodpressure/about.htm. Published 2021. Accessed April 2023.

**142.** Cornwell EY, Waite LJ. Social network resources and management of hypertension. *J Health Soc Behav.* 2012;53(2):215-231.

**143.** Ueno T, Nakagomi A, Tsuji T, Kondo K. Association between social participation and hypertension control among older people with self-reported hypertension in Japanese communities. *Hypertension Research.* 2022;45:1-6.

**144.** Magrin ME, D'Addario M, Greco A, et al. Social support and adherence to treatment in hypertensive patients: a meta-analysis. *Ann Behav Med.* 2015;49(3):307-318.

**145.** Shahin W, Kennedy GA, Stupans I. The association between social support and medication adherence in patients with hypertension: A systematic review. *Pharm Pract (Granada).* 2021;19(2):2300.

**146.** Pan J, Hu B, Wu L, Li Y. The Effect of Social Support on Treatment Adherence in Hypertension in China. *Patient Prefer Adherence.* 2021;15:1953-1961.

**147.** de Wit M, Trief PM, Huber JW, Willaing I. State of the art: understanding and integration of the social context in diabetes care. *Diabet Med.* 2020;37(3):473-482.

**148.** Brinkhues S, Dukers-Muijrers N, Hoebe C, et al. Socially isolated individuals are more prone to have newly diagnosed and prevalent type 2 diabetes mellitus – the Maastricht study. *BMC Public Health.* 2017;17(1):955.

**149.** Brinkhues S, Dukers-Muijrers N, Hoebe C, et al. Social Network Characteristics Are Associated With Type 2 Diabetes Complications: The Maastricht Study. *Diabetes Care.* 2018;41(8):1654-1662.

**150.** Altevers J, Lukaschek K, Baumert J, et al. Poor structural social support is associated with an increased risk of Type 2 diabetes mellitus: findings from the MONICA/KORA Augsburg cohort study. *Diabet Med.* 2016;33(1):47-54.

**151.** Meisinger C, Kandler U, Ladwig KH. Living alone is associated with an increased risk of type 2 diabetes mellitus in men but not women from the general population: the MONICA/KORA Augsburg Cohort Study. *Psychosom Med.* 2009;71(7):784-788.

**152.** Norberg M, Stenlund H, Lindahl B, Andersson C, Eriksson JW, Weinehall L. Work stress and low emotional support is associated with increased risk of future type 2 diabetes in women. *Diabetes Res Clin Pract.* 2007;76(3):368-377.

**153.** Strodl E, Kenardy J. Psychosocial and non-psychosocial risk factors for the new diagnosis of diabetes in elderly women. *Diabetes Res Clin Pract.* 2006;74(1):57-65.

**154.** Lidfeldt J, Nerbrand C, Samsioe G, Agardh CD. Women living alone have an increased risk to develop diabetes, which is explained mainly by lifestyle factors. *Diabetes Care.* 2005;28(10):2531-2536.

**155.** Kelly CS, Berg CA. Close relationships and diabetes management across the lifespan: The good, the bad, and autonomy. *Journal of Health Psychology.* 2018;26(2):226-237.

**156.** Wiebe DJ, Helgeson V, Berg CA. The social context of managing diabetes across the life span. *Am Psychol.* 2016;71(7):526-538.

**157.** Umeh K. Self-rated health and multimorbidity in patients with type 2 diabetes. *J Health Psychol.* 2022;27(7):1659-1678.

**158.** Song Y, Nam S, Park S, Shin IS, Ku BJ. The Impact of Social Support on Self-care of Patients With Diabetes: What Is the Effect of Diabetes Type? Systematic Review and Meta-analysis. *Diabetes Educ.* 2017;43(4):396-412.

**159.** Loprinzi PD, Ford MA. Effects of Social Support Network Size on Mortality Risk: Considerations by Diabetes Status. *Diabetes Spectr.* 2018;31(2):189-192.

**160.** LeRoy AS, Murdock KW, Jaremka LM, Loya A, Fagundes CP. Loneliness predicts self-reported cold symptoms after a viral challenge. *Health Psychol.* 2017;36(5):512-520.

**161.** Cohen S, Doyle WJ, Skoner DP, Rabin BS, Gwaltney JM, Jr. Social ties and susceptibility to the common cold. *JAMA.* 1997;277(24):1940-1944.

**162.** Stephen G, Siobhán H, Muldoon OT, Whittaker AC. Social cohesion and loneliness are associated with the antibody response to COVID-19 vaccination. *Brain Behav Immun.* 2022;103:179-185.

**163.** Akhter-Khan SC, Tao Q, Ang TFA, et al. Associations of loneliness with risk of Alzheimer's disease dementia in the Framingham Heart Study. *Alzheimer's & Dementia.* 2021;17(10):1619-1627.

**164.** Donovan NJ, Wu Q, Rentz DM, Sperling RA, Marshall GA, Glymour MM. Loneliness, depression and cognitive function in older U.S. adults. *Int J Geriatr Psychiatry.* 2017;32(5):564-573.

**165.** Duffner LA, Deckers K, Cadar D, Steptoe A, de Vugt M, Köhler S. The role of cognitive and social leisure activities in dementia risk: assessing longitudinal associations of modifiable and nonmodifiable risk factors. *Epidemiol Psychiatr Sci.* 2022;31:e5.

**166.** Domènech-Abella J, Mundó J, Haro JM, Rubio-Valera M. Anxiety, depression, loneliness and social network in the elderly: Longitudinal associations from The Irish Longitudinal Study on Ageing (TILDA). *J Affect Disord.* 2019;246:82-88.

**167.** Loades ME, Chatburn E, Higson-Sweeney N, et al. Rapid Systematic Review: The Impact of Social Isolation and Loneliness



## REFERENCES


on the Mental Health of Children and Adolescents in the Context of COVID-19. *Journal of the American Academy of Child & Adolescent Psychiatry.* 2020;59(11):1218-1239.e1213.

**168.** Choi KW, Stein MB, Nishimi KM, et al. An Exposure-Wide and Mendelian Randomization Approach to Identifying Modifiable Factors for the Prevention of Depression. *Am J Psychiatry.* 2020;177(10):944-954.

**169.** Van Orden KA, Witte TK, Cukrowicz KC, Braithwaite SR, Selby EA, Joiner TE, Jr. The interpersonal theory of suicide. *Psychol Rev.* 2010;117(2):575-600.

**170.** Shaw RJ, Cullen B, Graham N, et al. Living alone, loneliness and lack of emotional support as predictors of suicide and self-harm: A nine-year follow up of the UK Biobank cohort. *J Affect Disord.* 2021;279:316-323.

**171.** Mezuk B, Rock A, Lohman MC, Choi M. Suicide risk in long-term care facilities: A systematic review. *International journal of geriatric psychiatry.* 2014;29(12):1198-1211.

**172.** Du L, Shi HY, Qian Y, et al. Association between social support and suicidal ideation in patients with cancer: A systematic review and meta-analysis. *Eur J Cancer Care (Engl).* 2021;30(2):e13382.

**173.** Conwell Y, Van Orden K, Caine ED. Suicide in older adults. *Psychiatr Clin North Am.* 2011;34(2):451-468, ix.

**174.** King CA, Merchant CR. Social and interpersonal factors relating to adolescent suicidality: a review of the literature. *Arch Suicide Res.* 2008;12(3):181-196.

**175.** Troya MI, Babatunde O, Polidano K, et al. Self-harm in older adults: systematic review. *Br J Psychiatry.* 2019;214(4):186-200.

**176.** Brown EG, Gallagher S, Creaven A-M. Loneliness and acute stress reactivity: A systematic review of psychophysiological studies. *Psychophysiology.* 2018;55(5):e13031.

**177.** Leschak CJ, Eisenberger NI. Two Distinct Immune Pathways Linking Social Relationships With Health: Inflammatory and Antiviral Processes. *Psychosom Med.* 2019;81(8):711-719.

**178.** DiMatteo MR. Social Support and Patient Adherence to Medical Treatment: A Meta-Analysis. Health Psychology. 2004;23:207-218.

**179.** Shankar A, McMunn A, Banks J, Steptoe A. Loneliness, social isolation, and behavioral and biological health indicators in older adults. *Health Psychology.* 2011;30:377-385.

**180.** Hooker SA, Masters KS, Park CL. A Meaningful Life is a Healthy Life: A Conceptual Model Linking Meaning and Meaning Salience to Health. *Review of General Psychology.* 2018;22(1):11-24.

**181.** Cacioppo JT, Cacioppo S, Capitanio JP, Cole SW. The neuroendocrinology of social isolation. *Annu Rev Psychol.* 2015;66:733-767.

**182.** Mattos Dos Santos R. Isolation, social stress, low socioeconomic status and its relationship to immune response in Covid-19 pandemic context. *Brain Behav Immun Health.* 2020;7:100103.

**183.** Muscatell KA. Social psychoneuroimmunology: Understanding bidirectional links between social experiences and the immune system. *Brain Behav Immun.* 2021;93:1-3.

**184.** Robles TF. Annual Research Review: Social relationships and the immune system during development. *J Child Psychol Psychiatry.* 2021;62(5):539-559.

**185.** Donovan M, Mackey CS, Platt GN, et al. Social isolation alters behavior, the gut-immune-brain axis, and neurochemical circuits in male and female prairie voles. *Neurobiology of Stress.* 2020;13:100278.

**186.** Dill-McFarland KA, Tang Z-Z, Kemis JH, et al. Close social relationships correlate with human gut microbiota composition. *Scientific Reports.* 2019;9(1):703.

**187.** Guidi J, Lucente M, Sonino N, Fava GA. Allostatic Load and Its Impact on Health: A Systematic Review. *Psychother Psychosom.* 2021;90(1):11-27.

**188.** Furman D, Campisi J, Verdin E, et al. Chronic inflammation in the etiology of disease across the life span. *Nat Med.* 2019;25(12):1822-1832.

**189.** Yang YC, Schorpp K, Harris KM. Social support, social strain and inflammation: evidence from a national longitudinal study of U.S. adults. *Soc Sci Med.* 2014;107:124-135.

**190.** McHugh Power J, Carney S, Hannigan C, et al. Systemic inflammatory markers and sources of social support among older adults in the Memory Research Unit cohort. *J Health Psychol.* 2019;24(3):397-406.

**191.** Ershler WB, Keller ET. Age-associated increased interleukin-6 gene expression, late-life diseases, and frailty. *Annu Rev Med.* 2000;51:245-270.

**192.** Fortmann AL, Gallo LC. Social support and nocturnal blood pressure dipping: a systematic review. *Am J Hypertens.* 2013;26(3):302-310.

**193.** Teoh AN, Hilmert C. Social support as a comfort or an encouragement: A systematic review on the contrasting effects of social support on cardiovascular reactivity. *Br J Health Psychol.* 2018;23(4):1040-1065.

**194.** Li H, Xia N. The role of oxidative stress in cardiovascular disease caused by social isolation and loneliness. *Redox Biol.* 2020;37:101585.

**195.** Froemke RC, Young LJ. Oxytocin, Neural Plasticity, and Social Behavior. *Annual Review of Neuroscience.* 2021;44(1):359-381.

**196.** Hostinar CE. Recent Developments in the Study of Social Relationships, Stress Responses, and Physical Health. *Curr Opin Psychol.* 2015;5:90-95.

**197.** Scatliffe N, Casavant S, Vittner D, Cong X. Oxytocin and early parent-infant interactions: A systematic review. *Int J Nurs Sci.* 2019;6(4):445-453.

**198.** Silver L, Van Kessel P, Huang C, Clancy L, Gubbala S. *What Makes Life Meaningful? Views From 17 Advanced Economies.* Pew Research Center; 2021.



## REFERENCES


**199.** Petrova D, Garcia-Retamero R, Catena A. Lonely hearts don't get checked: On the role of social support in screening for cardiovascular risk. *Preventive Medicine.* 2015;81:202-208.

**200.** Kim ES, Strecher VJ, Ryff CD. Purpose in life and use of preventive health care services. *Proc Natl Acad Sci U S A.* 2014;111(46):16331-16336.

**201.** Southwick SM, Sippel L, Krystal J, Charney D, Mayes L, Pietrzak R. Why are some individuals more resilient than others: the role of social support. *World Psychiatry.* 2016;15(1):77-79.

**202.** Kivimaki M, Steptoe A. Effects of stress on the development and progression of cardiovascular disease. *Nature Reviews Cardiology.* 2018;15(4):215-229.

**203.** Schore AN. The effects of early relational trauma on right brain development, affect regulation, and infant mental health. *Infant Mental Health Journal.* 2001;22(1-2):201-269.

**204.** Chandola T, Brunner E, Marmot M. Chronic stress at work and the metabolic syndrome: prospective study. *BMJ.* 2006;332(7540):521-525.

**205.** McEwen BS. Neurobiological and Systemic Effects of Chronic Stress. *Chronic Stress.* 2017;1:2470547017692328.

**206.** Birmingham WC, Holt-Lunstad J. Social aggravation: Understanding the complex role of social relationships on stress and health-relevant physiology. *Int J Psychophysiol.* 2018;131:13-23.

**207.** Kent de Grey RG, Uchino BN, Trettevik R, Cronan S, Hogan JN. Social support and sleep: A meta-analysis. *Health Psychol.* 2018;37(8):787-798.

**208.** Kobayashi LC, Steptoe A. Social Isolation, Loneliness, and Health Behaviors at Older Ages: Longitudinal Cohort Study. *Ann Behav Med.* 2018;52(7):582-593.

**209.** Schrempft S, Jackowska M, Hamer M, Steptoe A. Associations between social isolation, loneliness, and objective physical activity in older men and women. *BMC Public Health.* 2019;19(1):74.

**210.** Christakis NA, Fowler JH. Social contagion theory: examining dynamic social networks and human behavior. *Stat Med.* 2013;32(4):556-577.

**211.** Driscoll SD. Barriers and facilitators to cervical cancer screening in high incidence populations: A synthesis of qualitative evidence. *Women Health.* 2016;56(4):448-467.

**212.** Miller TA, Dimatteo MR. Importance of family/social support and impact on adherence to diabetic therapy. *Diabetes Metab Syndr Obes.* 2013;6:421-426.

**213.** Mendonça G, Cheng LA, Mélo EN, de Farias Júnior JC. Physical activity and social support in adolescents: a systematic review. *Health Educ Res.* 2014;29(5):822-839.

**214.** Macdonald-Wallis K, Jago R, Sterne JAC. Social Network Analysis of Childhood and Youth Physical Activity: A Systematic Review. *American Journal of Preventive Medicine.* 2012;43(6):636-642.

**215.** Christakis NA, Fowler JH. The Collective Dynamics of Smoking in a Large Social Network. *New England Journal of Medicine.* 2008;358(21):2249-2258.

**216.** Moore S, Teixeira A, Stewart S. Effect of network social capital on the chances of smoking relapse: a two-year follow-up study of urban-dwelling adults. *Am J Public Health.* 2014;104(12):e72-76.

**217.** Blok DJ, de Vlas SJ, van Empelen P, van Lenthe FJ. The role of smoking in social networks on smoking cessation and relapse among adults: A longitudinal study. *Prev Med.* 2017;99:105-110.

**218.** DuBois DL, Portillo N, Rhodes JE, Silverthorn N, Valentine JC. How Effective Are Mentoring Programs for Youth? A Systematic Assessment of the Evidence. *Psychological Science in the Public Interest.* 2011;12(2):57-91.

**219.** Steiner RJ, Sheremenko G, Lesesne C, Dittus PJ, Sieving RE, Ethier KA. Adolescent Connectedness and Adult Health Outcomes. *Pediatrics.* 2019;144(1).

**220.** Beal DJ, Cohen RR, Burke MJ, McLendon CL. Cohesion and Performance in Groups: A Meta-Analytic Clarification of Construct Relations. *Journal of Applied Psychology.* 2003;88:989-1004.

**221.** Tu M, Cheng Z, Liu W. Spotlight on the Effect of Workplace Ostracism on Creativity: A Social Cognitive Perspective. *Frontiers in Psychology.* 2019;10.

**222.** Kwan HK, Zhang X, Liu J, Lee C. Workplace Ostracism and Employee Creativity: An Integrative Approach Incorporating Pragmatic and Engagement Roles. *Journal of Applied Psychology.* 2018;103:1358-1366.

**223.** Patel A., Plowman S. The Increasing Importance of a Best Friend at Work. In. *Workplace:* Gallup Inc.,; 2022.

**224.** Mann A. *Why We Need Best Friends at Work.* Gallup, Inc.; 2018.

**225.** Velando-Soriano A, Ortega-Campos E, Gómez-Urquiza JL, Ramírez-Baena L, De La Fuente EI, Cañadas-De La Fuente GA. Impact of social support in preventing burnout syndrome in nurses: A systematic review. *Japan Journal of Nursing Science.* 2020;17(1):e12269.

**226.** White C, Green RA, Ferguson S, et al. The influence of social support and social integration factors on return to work outcomes for individuals with work-related injuries: a systematic review. *Journal of occupational rehabilitation.* 2019;29(3):636-659.

**227.** Chetty R, Jackson MO, Kuchler T, et al. Social capital I: measurement and associations with economic mobility. *Nature.* 2022;608(7921):108-121.

**228.** Chetty R, Jackson MO, Kuchler T, et al. Social capital II: determinants of economic connectedness. *Nature.* 2022;608(7921):122-134.

**229.** Wilson J. Volunteering. *Annual review of sociology.* 2000:215-240.

**230.** Jastrzab J, Giordono L, Chase A, et al. *Serving Country and Community: A Longitudinal Study of Service in AmeriCorps.* Washington, DC: Corporation for National and Community Service; 2004.

**231.** Spera C, Ghertner R, Nerino A, DiTommaso A. Out of work? Volunteers Have Higher Odds of Getting Back to Work. *Nonprofit and Voluntary Sector Quarterly.* 2015;44(5):886-907.



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# How Roads Have Transformed the Natural World

Ben Goldfarb

Robert Alexander / Contributor

When alien archaeologists exhume the rubble of human civilization, they may conclude that our raison d'être was building roads. Some 40 million miles of roadways encircle the Earth, from the continent-spanning Pan-American Highway to the hundred thousand miles of illegal logging routes that filigree the Amazon. Our planet is burdened by perhaps 3,000 tons of infrastructure for every human, nearly a third of an Eiffel Tower per person. Roads predate the wheel: Mesopotamian builders began laying mud-brick paths in 4000 B.C.E., centuries before anyone thought to drop a chariot onto a couple of potter's disks. Today it's impossible to imagine life without the asphalt arteries that connect goods with markets, employees with jobs, families with each other. "Everything in life is somewhere else," wrote E.B. White, "and you get there in a car."

Roads are both logistical essentials and cultural artifacts. They epitomize freedom—the "architecture of our restlessness," per Rebecca Solnit, the "two lanes [that] take us anywhere," per Bruce Springsteen. To us, roads signify connection and escape; to other life-forms, they spell death and division. Sometime during the 20th century, scientists have written, roadkill surpassed hunting as "the leading direct human cause of vertebrate

 

mortality on land." Name your environmental ill—dams, poaching, megafires—and consider that roads kill more creatures with less fanfare than any of them. (More birds die on American roads every week than were slain by the Deepwater Horizon oil spill, with the road deaths accompanied by a fraction of the hand-wringing.) And it's only getting worse as traffic swells. A half-century ago, just 3 percent of land-dwelling mammals met their end on a road; by 2017 the toll had quadrupled. It has never been more dangerous to set paw, hoof or scaly belly on the highway.

Roads distort the planet in other, more insidious ways. No sooner was Rome's Via Cassia completed around 100 B.C.E. than its surface began to shed sediment into Lago di Monterosi, spawning algal blooms that permanently distorted the lake's ecosystem. *Phytophthora lateralis,* an invasive fungus that attacks cedar trees, hitchhikes in the patterns of truck tires. The little red fire ant, a merciless insect notorious for stinging the eyes of elephants, has exploited logging tracks to spread through Gabon 60 times faster than it would have otherwise. A 2000 study found that pavement itself blanketed less than 1 percent of the United States, yet its influence—the "road-effect zone," to use ecological jargon—covered up to 20 percent. Park your car on the shoulder and bushwhack half a mile into the woods, and you'll still see fewer birds than you would in an unroaded wilderness. Hike two miles more, and you'll still see fewer mammals. If you're a Kerouac reader, you grew up steeped in the dogma that highways represent freedom. If you're a grizzly bear, they might as well be prison walls.

The repercussions of roads are so complex that it's hard to pinpoint where they end. British Columbia's caribou herds have dwindled to furtive bands, in part because logging and mining roads have permitted the ingress of wolves—a human-caused disaster disguised as natural predation. Nearly a fifth of America's greenhouse gas emissions are coughed out by cars and trucks, and the transportation sector is the fastest-growing contributor to climate change; meanwhile, the rise of electric vehicles, whose batteries depend on lithium and other metals, has catalyzed a mining boom that threatens to disfigure landscapes in places as disparate as Chile, Zimbabwe and Nevada. Even habitat loss, the most thorough eraser of wildlife, is a road problem. Before you can log Alaska's rainforests or convert Bornean jungles into oil-palm monocultures, you need roads to transport the machinery in and the product out. ...

Yet roads select winners as well as losers. Arizona's highways funnel rainfall into ditches and thus soften desert soils for pocket gophers, whose tunnels parallel the shoulder like subway lines. Vultures, ravens and other cunning scavengers are ascendant, their diets subsidized by roadkill. Butterflies whose prairies have been devoured by cornfields find succor in unkempt strips of roadside milkweed. In Britain such habitat is called the "soft estate"—a suggestion that roads are capable of creating new ecosystems, even as they shatter existing ones. A biologist once led me beneath a highway bridge to show me hundreds of little brown bats roosting in its crevices, seemingly unbothered by the traffic thumping overhead.

Considering the outsize effects of roads, it's perhaps surprising that they didn't truly receive their scientific due until the late 20th century. One afternoon in 1993, a landscape ecologist named Richard Forman was standing in his Harvard University office with a few students, admiring a satellite photograph of a forest. Forman was expounding on the forest's features—where the water flowed, why people had put houses where they had, how the animals moved through it—when he paused. "I noticed the long slice going diagonally across the image," he recalled to me. "It was a two-lane road through the forest. I said, gee, we know a lot about the ecology of everything else in this image, but we don't know much about the ecology of that." Inspired by inattention, Forman soon coined an English term: "road ecology," defined loosely as the study of how "life change[s] for plants and animals with a road and traffic nearby."

 

He did not immediately attract disciples. When a major government committee invited Forman to present his new field to transportation higher-ups the next year, he was met with polite laughter. "You're not here to make us stop running over animals, are you?" one engineer asked, cocking an eyebrow. As the 1990s wore on, though, road ecology gained steam. Forman and other pioneers published papers, wrote textbooks, held conferences that lured curious officials. "All of a sudden," Forman said, "it became mainstream."

Road ecology inverts our oldest joke about animals and transportation: Why did the chicken cross the road? Embedded in that chestnut is an assumption—that the road is inviolable and eternal, as fixed in its course as a river. The road is a given; it's the fowl whose actions demand explanation. But the riddle's logic is backward. It's the animals who have always moved, the road that's the upstart. A better question might be: Why did the road cross the land?

This framing isn't always comfortable. When we don't ignore roads, we nevertheless dismiss their toll as the inevitable cost of modernity. …

This is particularly true in the United States, home to the world's longest road network, at four million miles. Our midcentury automotive revolution spawned not only highways but also parking lots, driveways, suburbs, pipelines, gas stations, car washes, drive-throughs, tire shops and strip malls—a totalizing ecosystem engineered for its dominant organism, the car. For all its grandeur, though, America's highway network is relatively static. Although we spend almost $200 billion on our roads annually, most goes toward repair rather than new construction. … [O]ur country's asphalt limbs have mostly ceased to elongate, petrified into something like their eternal shape.

Instead, we're exporting our autocentric lifestyle. More than 25 million kilometers of new paved road lanes will be built worldwide by 2050, many through the world's remaining intact habitats, a concrete wave that the ecologist William Laurance has described as an "infrastructure tsunami." Astoundingly, as of 2016, three-quarters of the infrastructure that will exist by the middle of this century had yet to be built. Although it's easy to denounce the tsunami, I benefit from roads as much as anyone: I eat avocados trucked from California; I get pizza delivered to my doorstep; I rely on America's marvel of a highway system to reach friends and hospitals and airports. (And I confess to feeling what one Volkswagen ad campaign called *Fahrvergnügen,* the pleasure of driving.) Roads pose the same queasy conundrum as climate change: Having profited wildly from growth, can wealthy nations deny less-developed countries the benefits of connectivity?

Road ecology offers one path through this thicket. North America and Europe constructed their road networks with little regard for how they would affect nature and even less comprehension of how to blunt those effects. Today, in theory, we know better. Road ecology has revealed the perils of reckless development and pointed us toward solutions. Over the last several decades, its practitioners have constructed bridges for bears, tunnels for turtles, rope webs that allow howler monkeys to swing over highways without descending to the forest floor. On Christmas Island, red crabs clamber over a steel span during their beachward migrations; in Kenya, elephants lumber beneath highways and railroads via passages as tall as two-story houses. And road ecology has yielded more than crossings: We've also learned to map and protect the migrations of cryptic animals, to design roadsides that nourish bees and butterflies, and to deconstruct the derelict logging tracks that lace our forests—proof that old mistakes need not be permanent.

Here in the U.S., we're entering a period that might fairly be considered the golden age of road ecology. Once, we ignored our infrastructure's cataclysmic ecological toll; today, we're newly focused on remediating it. The

 

How Roads Have Transformed the Natural World

2021 Infrastructure Investment and Jobs Act alone allocated billions of dollars to the cause: Its programs include a $350 million grant program for new wildlife crossings; $250 million to fix or obliterate derelict roads and trails in national forests; and $1 billion to repair road culverts that block salmon, herring and other migratory fish from reaching their spawning grounds. The coming years will undoubtedly be transformative ones for our road network. Whether we can ever truly undo the harms of our concrete-encrusted world is far less certain.

*Excerpted from* Crossings: How Road Ecology Is Shaping the Future of Our Planet *by Ben Goldfarb (W. W. Norton & Company). Copyright © 2023 by Ben Goldfarb. All rights reserved*.

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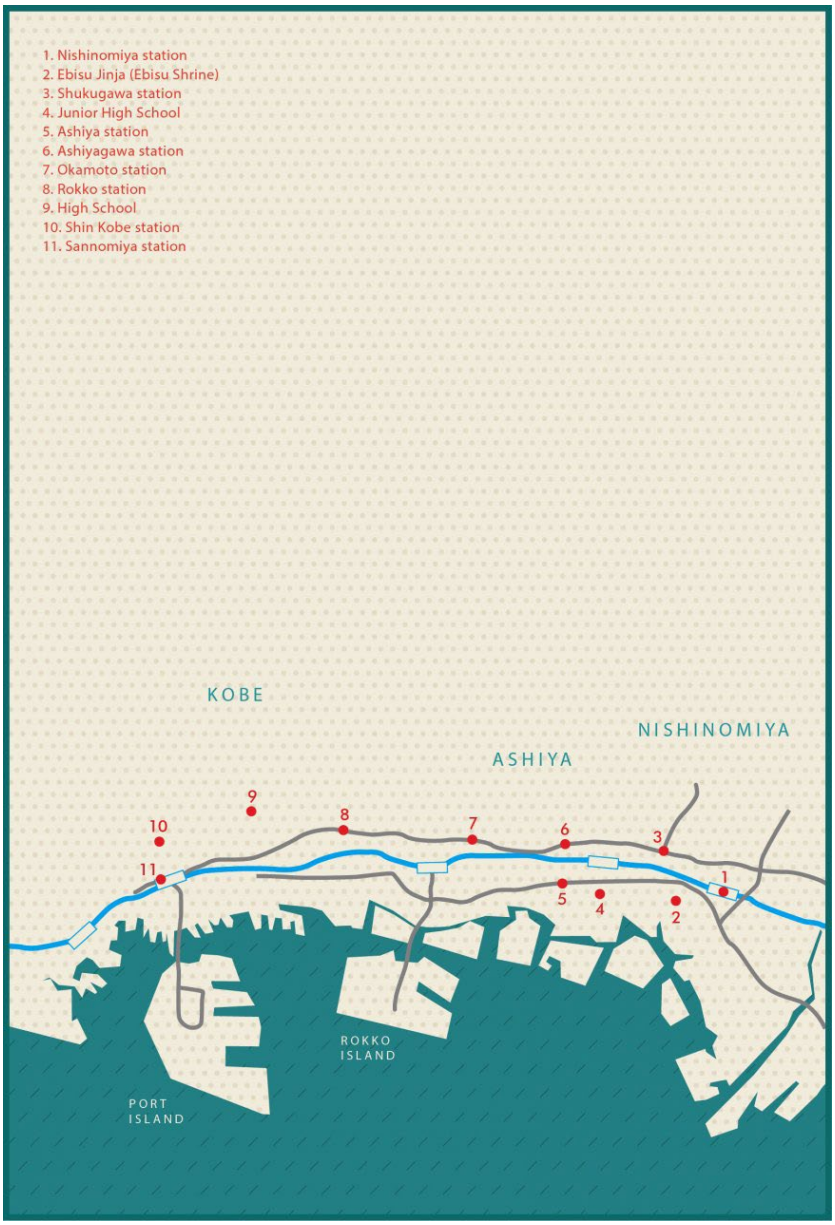


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# A Walk to Kobe

Haruki Murakami
Translated by Philip Gabriel

'What I'm talking about is a different sea, and different mountains.' Haruki Murakami walks to his hometown after the Great Hanshin earthquake of 1995.

1

In May of 1997, two years after the massive earthquake in Kobe, I hit upon the idea of taking a leisurely, solitary walk from Nishinomiya to Sannomiya in downtown Kobe. I happened to be staying in Kyoto at the time for work, and continued on to Nishinomiya. On the map it's about fifteen kilometres west from there to Kobe. Not exactly a stone's throw away, but not such a gruelling distance, and besides, I'm a pretty confident walker.

I was born in Kyoto, but soon afterwards my family moved to Shukugawa, a neighbourhood in Nishinomiya. And not long after that we moved again, closer to

Kobe, to Ashiya, where I spent most of my teenage years. My high school was in the hills above the city, so naturally downtown Kobe was where I headed when I wanted to have a good time, specifically around Sannomiya. I became a typical *Hanshin-kan* boy, the term referring to the area that lies between Osaka and Kobe. Back then – and probably nowadays as well – this was a great place to grow up. It's quiet and laid-back, with an open, relaxed feeling about it, and it's blessed with the ocean, mountains and a large city nearby. I loved going to concerts, hunting for cheap paperbacks in used bookstores, hanging out in jazz cafes, and enjoying Art Theatre Guild new-wave films. My favourite look at the time? VAN jackets, of course.

But then I moved to Tokyo for college, got married and started working, and seldom travelled back to this strip of land between Osaka and Kobe. There were times I'd return, of course, but as soon as I finished what I had to do I'd always hop on the bullet train and head straight back to Tokyo. I had a busy life, and I spent a lot of time abroad. And there were a couple of personal reasons as well. Some people are constantly being pulled back to their home town, while others feel like they can never go back. In most cases it's as if fate separates the two groups, and it has little to do with how strong your feelings are towards the place. Like it or not, I seem to belong to the second group.

For years my parents lived in Ashiya, but when the Hanshin Earthquake hit in January 1995, their house was too damaged to stay in and they soon moved to Kyoto. So, apart from all the memories I'd stored up for myself (my valuable property), there was no longer any actual connection between me and the Hanshin-kan area. Strictly speaking, it's not my home town any more. I feel a deep sense of loss at this fact, as if the axis of my memories is faintly, but audibly, creaking within me. It's a physical sensation.

Maybe it's exactly *because* of that that I wanted to take a walk there, alert and attentive to what I might discover. Perhaps I wanted to see for myself how this *home town* I'd lost all obvious connections with would appear to me now. How much of a shadow (or a shadow of a shadow) of myself I would discover there?

I also wanted to see what effect the Hanshin Earthquake had had on the town I grew up in. I visited Kobe several times after the quake, and was frankly shocked by the extent of damage. But now, some two years later, when the town seemed finally to have righted itself, I wanted to see with my own eyes what transformations had taken place – what this awful violence had stolen from the town, and what it had left behind. There had to be at least some connection, I felt, with who I am now.

Clad in rubber-soled walking shoes, shouldering a backpack with a notebook and small camera, I got off at the train at Nishinomiya station and set off at a leisurely pace towards the west. The weather was so bright and sunny I wore sunglasses. The first place I came to was the shopping area near the south exit of the station. In elementary school I often used to ride my bike over there to buy things. The city library was nearby, too, and whenever I had time I'd hang out there and pore

 

through every young adult book I could lay my hands on. There was also a craft shop close by where I stocked up on plastic models. So this place brought back a rush of memories.

I hadn't been here for a long time, and the shopping area had changed almost beyond recognition. How much of this was due to the normal changes over time, and how much was because of the physical devastation brought on by the earthquake, I really couldn't say. Even so, the scars left by the earthquake were plain to see. Where buildings had collapsed, vacant lots now dotted the area like so many missing teeth, with prefab temporary stores in between as if to connect them all. Summer grass grew in the roped-off vacant lots, and the asphalt streets were filled with ominous cracks. Terrible destruction was in evidence all around, as if the area was some ancient ruins. Compared to the downtown shopping district of Kobe, which the world had focused on, and which had rapidly been rebuilt after the quake, the blank spaces here struck me as somehow heavy and dull, with a quiet depth to them. Of course this wasn't only true of the Nishinomiya shopping district. There must be many places around Kobe that still bear the same sort of wounds, but that are mostly forgotten.

Past the shopping district and across the main street is Ebisu Shrine. It's a very large shrine, with thick woods within its precincts. When I was a small child, my friends and I loved to play here, and it hurt to see the visible scars there now. Most of the large stone lights lining the Hanshin highway were missing the topmost lantern part. These were scattered on the ground below, like heads lopped off by a sharp sword. The remaining bases had become a row of senseless, purposeless stone statues, solemnly silent, like symbols from a dream.

The old stone bridge across the pond where I used to catch shrimp as a child (using a simple technique: I would tie a string around an empty bottle, put in noodle powder as bait, lower it into the water and the shrimp would go into the bottle and then I would pull it up) had collapsed and remained that way. The water in the pond was dark and muddy and turtles of indiscriminate ages lay sprawled on dry rocks, basking in the sun, their minds no doubt bereft of any thoughts. Terrible destruction was in evidence all around, as if the area was some ancient ruins. Only the deep woods were the same as I remembered from childhood, dark and still, beyond time.

I sat down in the shrine grounds under the early-summer sun, and gazed around again at the surroundings, trying to get used to what I was seeing. Absorbing and accepting this scenery as naturally as I could, mentally and viscerally. Trying to remember how I was back then. But this was all going to take a long time, as you might imagine.

2

I strode on from Nishinomiya to Shukugawa. It was not yet noon, but sunny enough that, walking briskly, I started to perspire. I didn't need a map to tell

 

me roughly where I was, but I had no memory of the individual streets. I must have walked down these streets hundreds of times, but now I was drawing a complete blank. Why couldn't I recall them? It was strange. I felt bewildered, as if I'd come home to find all the furniture replaced.

The reason was soon clear to me. Places that used to be empty lots weren't empty any more, and places that hadn't been empty now were – like photo negatives and positives replacing each other. In most cases the former were empty lots that were now residences, the latter where old houses had been destroyed in the earthquake. These before-and-after images had a synergistic effect, adding a fictitious wash to my memories of how the town used to be.

The old house I had lived in near Shukugawa was gone, replaced by a row of town houses. And the grounds of the nearby high school were filled with temporary housing put up for survivors of the quake. Where my friends and I used to play baseball, the people who lived in these prefab shelters had hung their laundry and futons out to air, in what now seemed like a tight, cramped space. Try as I might to find vestiges of the past, there were almost none. The water in the river still flowed as clean and pure as before, but it gave me an odd sensation to see how the riverbed was now neatly lined with concrete.

I walked on for a while in the direction of the sea and stopped by a local sushi shop. It was a Sunday afternoon, and they were busy with takeout orders. The young assistant who'd gone out on deliveries didn't come back for a long time, and the owner was hard-pressed to keep up with the phone calls. A typical scene you'd find anywhere in Japan. I waited for my order to come, sipping a beer and half watching the TV. The governor of Hyogo prefecture was talking with someone on a show about how postquake reconstruction was going. I'm trying to remember now exactly what he said, but for the life of me can't recall a single word.

As a child, when I climbed the banks of the river, the sea was spread out right in front of me, with nothing blocking the view. I used to go swimming there in the summer. I loved the ocean and loved to swim. I went fishing, too, and took my dog for a walk there every day. Sometimes I just liked to sit down and do nothing. And sometimes I'd sneak out of the house at night, go to the sea with my friends and gather driftwood and light a bonfire. I loved the smell of the sea, its far-off roar, and all that it brought with it.

But now the sea isn't there any more. They cut down the mountains, hauled all the dirt off to the sea with trucks and conveyor belts and filled it in. With both the mountains and sea so close by, this area is perfect for that kind of construction work. Neat little residential communities have sprung up where the mountains used to be, and similarly neat little residential communities have popped up on the landfill. All this happened after I moved to Tokyo, during the era of high growth in Japan, when the country was in the throes of a nationwide construction boom.

I own a house now in a town on the seashore in Kanagawa prefecture near Tokyo, and travel back and forth between there and Tokyo. Unfortunately, or very unfortunately, I should say, this seaside town reminds me more of my home town than my home town does. The area has green mountains, and a wonderful swimming beach. I want to preserve these as best I can, because once natural scenery is gone, it's gone forever. …

Past the banks of the river, the area around what used to be the Koroen seaside resort had been filled in to make a kind of cosy little cove, or pond. Windsurfers were there, doing their best to catch the wind. Just to the west, on what was Ashiya beach, stands a row of high-rise apartment buildings, like so many blank monoliths. On the shore, some families that have driven there in their station wagons and minivans are using small propane tanks to have a barbecue. So-called *outdoor activities.* They're grilling meat, fish and vegetables, and the whitish smoke silently rises like a beacon into the sky on this happy Sunday scene. There's hardly a cloud in the sky. An almost perfect May tableau. Still, as I sit there on the concrete bank and gaze at where the real sea used to be, everything here, like a tyre leaking air, slowly, and quietly, loses its sense of reality.

In the midst of this placid scene it's hard to deny the vestiges of violence. That's how it struck me. A part of those violent tendencies lies hidden right below our feet, while another part is hidden within us. One is a metaphor for the other. Or perhaps they are interchangeable. Lying here, asleep, like a pair of animals having the same dream.

I crossed a small river and went into Ashiya. I walked past my old junior high school, past the house I used to live in, and came to the Ashiya train station. A poster in the station announced a game at 2 p.m. that day at Koshien Stadium in Osaka between the Hanshin Tigers and Yakult Swallows baseball teams. Seeing it, I had the sudden urge to go. I made a quick change of plans and jumped on the train. The game had just begun, so if I went now, I thought, I should be there in time for the third inning. I could resume my walk tomorrow.

Koshien Stadium had changed little from when I was child. Like I'd stumbled into a time warp, I felt a keen nostalgic sense of not belonging – an odd turn of phrase, admittedly. About the only things that had changed were the lack of hawkers shouldering polka-dot tanks of Calpis, selling the fermented milk drink (seems like there aren't many people in the world who drink Calpis any more), and the outfield scoreboard, which was now electronic (and hard to decipher during the day). But the colour of the dirt on the field was the same as before, as was the green of the grass, and the Hanshin fans were as famously boisterous as ever. Earthquakes, revolutions, wars and centuries can come and go, but Hanshin fans are eternal.

The game turned out to be a pitcher's duel between Kawajiri and Takatsu, with Hanshin winning 1–0. You might think the one-run difference meant it was a thrilling game but it wasn't, not by any stretch of the imagination. If anything, it was

 

a highlight-free sort of game. To put it even more bluntly, a game not worth seeing. Especially for those of us in the outfield seats. As the sun got stronger we grew horribly thirsty. I had a few cold beers and, predictably, dozed off on the bleachers. When I woke up I had totally lost track of where I was. (Where the hell am I? I wondered.) The shadows from the floodlights had meandered in my direction, nearly reaching me.

3

I checked into a new little hotel in Kobe. Most of the guests were groups of young women. ... The next morning I got up at six and took the pre-rush-hour train to Ashiyagawa station, and restarted my mini walking tour. Unlike the day before, the sky was covered with clouds, the air a bit chilly. The weather report in the paper confidently predicted rain in the afternoon (and of course they were spot on. In the evening I got drenched).

...

I walked along a road in the foothills where the railroad line runs, taking little detours as I made my way west, and in about thirty minutes had entered Ashiya. It is a long, narrow town running north and south. Walk east or west and you've soon left it. On either side of the road there were empty lots here, too, left over from the earthquake, and a few deserted houses tilting to one side. The soil in the Hanshin-kan area differs from that in Tokyo. It's a sandy mountainous area, so the earth is smooth and whitish, which made the empty lots stand out all the more. The area was thick with green summer weeds, making the contrast even more striking. I pictured a large surgical scar on the skin of someone close to me, an image that sent a physical, stabbing pain right through me, a pain not tethered to time or place.

Naturally there was more than just vacant lots covered in weeds. I did run across several construction sites. I imagine that in less than a year there will be rows of newly built houses here, so many I probably wouldn't recognize the place. Brand-new roof tiles, sparkling brilliantly in the fresh rays of the sun. By then there might be nothing left in common between the scenery here and me as a person. (Most likely there won't be.) Between us (probably) stands a forced divide exposed by an overwhelming destructive device, namely the earthquake. I gazed up at the sky, breathed in the slightly cloudy morning air, and thought about this land that had made me into the person I am, and about the person whom this land had made. About the sort of things we have no control over.

When I arrived at Okamoto station, the next station over, I thought I'd stop by a coffee shop – any place would do – and order their set breakfast. I hadn't eaten anything all morning. But none of the coffee shops were open yet.

 

It wasn't that kind of town, I remembered. Reluctantly, I bought a CalorieMate energy bar at a Lawson's beside the road, sat on a park bench and silently ate it, washing it down with a can of coffee. I used the time to jot down notes on what I'd seen on the journey so far. After a short break I pulled out the paperback copy of Hemingway's *The Sun Also Rises* from my pocket and took up where I'd left off. I'd read the novel in high school, and had happened to start it again in bed in the hotel and had become totally lost in the story. I wonder why I never realized before what a great novel it is. This realization gave me an odd sensation. I guess my mind must have been elsewhere back then.

There was no breakfast service to be found at the next station, Mikage, either, so I went on silently trudging along the train tracks, lost in dreams of strong, steaming hot coffee and slices of thick, buttered toast. As before, I passed a number of empty lots and construction sites. Several Mercedes-Benz E-Class sedans glided by, taking children to school or the station, I imagine. The cars didn't have a single smudge or a scratch. Like symbols have no substance, and the flow of time no goal. All unconnected to the earthquake, or to violence. Most likely.

In front of Rokko station I made a small concession, went into a McDonald's, ordered an Egg McMuffin set (360 yen) and was able finally to appease the hunger that had been growling inside me like the roar of the sea. I decided to take a thirty-minute break. It was now 9 a.m. Going inside a McDonald's at 9 a.m., I felt like I'd been absorbed into a huge McDonald's-esque imaginary reality. Or become part of some mass unconscious. But really, all that surrounded me was my own individual reality. Obviously. For better or for worse, it's just that that individualism had, temporarily, no place to go.

I'd managed to make it this far, so I decided to climb the steep slope that led to my old high school. A light sheen of sweat broke out on my forehead. In high school I always rode a packed bus to school, but now I walked the same road under my own steam. In the spacious playing field that had been carved out of the mountain slopes, girl students were playing handball as part of their gym class. There was an unearthly quiet all around, except for the occasional shouts of the girls. It was so completely still it felt like I'd stumbled into a level of space I shouldn't be in. Why this utter silence?

I gazed at Kobe harbour, sparkling leadenly far below, and listened carefully, hoping to pick up some echoes from the past, but nothing came to me. Just the sounds of silence. That's all. But what are you going to do? We're talking about things that happened over thirty years ago.

Over thirty years ago. There is one thing I can say for certain: the older a person gets, the lonelier he becomes. It's true for everyone. But maybe that isn't wrong. What I mean is, in a sense our lives are nothing more than a series of stages to help us get used to loneliness. That being the case, there's no reason to complain. And besides, who would we complain to, anyway?

4

...

Sorry to say, I still haven't found a clear, logical answer to these questions. I haven't arrived at any definite destination. All I'm able to do at this point is, through my uncertain prose, serve up in an anticlimactic vessel the actual path my thoughts (and my gaze and legs) led me to. I hope you will understand this. Ultimately I'm the kind of person who can only make progress through moving my legs, moving my body, through a step-by-step, halting, physical process. It takes time. A miserably long amount of time. I just hope it won't be too late.

I finally arrived in Sannomiya. By this time I was starting to smell pretty rank. It wasn't such a long distance, though further than your typical morning stroll. In the hotel room I took a hot shower, washed my hair and gulped down a cold bottle of mineral water from the fridge. I took out a fresh change of clothes from my bag. Navy-blue polo shirt, blue cotton sports coat and beige chinos. My legs were a bit swollen, but there was nothing I could do about it. Just like I couldn't extract the vague questions that lay dull and unresolved in my head.

There wasn't anything in particular I wanted to do, so I went to see a film that caught my eye, one starring Tom Cruise. Not all that moving a film, but not so bad, either. I just took a rest, passing the time. Two hours of my life passed by – not so movingly, but not so badly, either. Evening was coming on as I exited the theatre, and I strolled up towards the hills to a little restaurant. I sat at the counter, ordered a seafood pizza and a draught beer. I was the only customer who was by himself. Maybe it was just my imagination, but everyone else there seemed really happy. The couples looked contented, and a group of men and women were laughing uproariously. Some days are just like that.

The seafood pizza they brought me had a little paper tag on it announcing that *This pizza you are about to enjoy is the 958,816th pizza made by our restaurant.* I couldn't follow. 958,816? What sort of message was I supposed to read into this? When I was young, I often used to come to this place with my girlfriend, down a few cold beers, and eat a freshly baked pizza with the same kind of numbered tag. We'd talk about our future. And of all the predictions we made then, not a single one came true. But this was a long, long time ago. Back when there was still a sea here, back when there were mountains.

Not that there aren't still sea and mountains here. Of course there are. What I'm talking about is a different sea, and different mountains. Different from the ones here now. As I sip my second beer, I flip open my paperback copy of *The Sun Also Rises* and pick up where I left off. The lost story of a lost generation. I'm quickly lured back into their world.

When I finally leave the restaurant, it's raining, as predicted, and I get wet. Wretchedly wet, soaked to the bone. But by this point it's too much trouble to buy an umbrella.

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# 35 years after the Berlin Wall opened, fragments of East Germany's border remain

The evening sun lights remains of the Berlin Wall at the official Berlin Wall memorial site at Bernauer Strasse, in Berlin, Germany, Wednesday, Oct. 23, 2024. (AP Photo/Markus Schreiber)

BERLIN (AP) — Most of communist East Germany's heavily fortified border was torn down quickly after it was opened in 1989, but there are still places where visitors can see the remains of the Berlin Wall and other sections of the frontier.

East Germany closed the border in Berlin on Aug. 13, 1961, and expanded the Wall into an increasingly elaborate fortification snaking through the city and around the capitalist enclave of West Berlin.

The Wall plugged the last gap in the border between east and west. East Germany's leadership had already sealed off the country's main frontier with West Germany, snaking from the Baltic Sea to Czechoslovakia, in 1952. It stayed that way until the border was opened on Nov. 9, 1989.

The Bornholmer Strasse crossing in Berlin was the first to open that night. Border guards, who hadn't received orders to let anyone pass, gave way under pressure from a large crowd demanding to be let through after an off-handed announcement of new regulations by Politburo spokesperson Günter Schabowski.

Today, a section of Wall slabs with photos of those events and a series of plaques marking the night's main developments — including an alert sent by The Associated Press' German service — stands at the former crossing.

The longest section of Wall remaining in Berlin is the East Side Gallery, where the once-gray concrete slabs are covered with murals that were painted by 118 artists after the opening of the border.

Visitors walk along remains of the Berlin Wall at the official Berlin Wall memorial site at Bernauer Strasse, in Berlin, Germany, Wednesday, Oct. 23, 2024. (AP Photo/Markus Schreiber)

Otherwise, the Wall has largely disappeared now and much of the former "death strip" — between the exterior wall that faced West Berlin and an interior wall that faced east — has been built over.

Among the exceptions is a strip of the former border at the Bernauer Strasse memorial site in downtown Berlin, and there are fragments dotted around elsewhere in the city and on its edges.

In most cases, the main East-West German border outside Berlin consisted of heavily fortified fences rather than walls. There were a few exceptions, however: most famously in the village of Moedlareuth, divided between Bavaria and the eastern region of Thuringia, which earned the nickname "Little Berlin." Part of Moedlareuth's border can still be seen today.

Germany was reunified on Oct. 3, 1990, less than a year after the border opened.

The evening sun shines on remains of the Berlin Wall at the official Berlin Wall memorial site at Bernauer Strasse, in Berlin, Germany, Wednesday, Oct. 23, 2024. (AP Photo/Markus Schreiber)

People gather at a painting at the so-called East Side Gallery, a popular place for street art on remains of the Berlin Wall in Berlin, Germany, Wednesday, Oct. 30, 2024. (AP Photo/Markus Schreiber)

People gather at a painting at the so-called East Side Gallery, a popular place for street art on remains of the Berlin Wall in Berlin, Germany, Wednesday, Oct. 30, 2024. (AP Photo/Markus Schreiber)

Remains of the Berlin Wall stand next to graves on a cemetery in Central Berlin, Germany, Tuesday, Oct. 22, 2024. (AP Photo/Markus Schreiber)

Original segments of the Berlin Wall for sale stand on a closed property in Teltow, near Berlin, Germany, Wednesday, Oct. 23, 2024. (AP Photo/Markus Schreiber)

A view out of a border control tower on the original remains of a wall separating the two parts of the village Mödlareuth during the German division in East and West Germany is pictured on Thursday, Oct. 24, 2024. (AP Photo/Markus Schreiber)

Stones on the street mark the course of the former Berlin Wall near the Brandenburg Gate in Berlin, Monday, Nov. 4, 2024. (AP Photo/Markus Schreiber)

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# Dad, ballpark will live on in shared memories

## By Ann Killion, Dec 22, 2013

Candlestick Park has been my part-time office for more than two decades. But, from a sentimental standpoint, it has always felt more like a room in my childhood home, full of faded memories, familiar smells and an odd kind of (cold, windy and damp) comfort.

Candlestick Park will always be for me, first and foremost, not about Joe Montana or Willie Mays but about my dad.

When a team moves to swanky new digs and the building left behind becomes an empty shell, and eventually a pile of rubble, where do all our memories go? The Stick is packed with the ghosts of family legends, traces of generations' worth of outings, spirits of memorable moments of bonding.

My dad's spirit is there. My 100 percent Irish father loved good stories, a big laugh and sports drama. And Candlestick Park provided plenty of all three.

My father was thrilled when the Giants moved west, standing on Montgomery Street to greet them as ticker tape showered down upon him and my older brother, who was perched on his shoulders. Dad was excited when Candlestick Park opened. When then-Vice President Richard Nixon dubbed it "one of the most beautiful baseball parks of all time," it was probably the only time my father agreed with the man.

My father made it to the first World Series at Candlestick Park in 1962, waiting through four days of rain delays that puddled water on the field. That was nothing compared to the 27 years he'd have to wait until he saw his next World Series there, and by that time Candlestick was considered decrepit and outdated. But our family loyalty to the place was strengthened even then because my dad and brother, as well as everyone else, emerged unscathed from the 1989 earthquake.

Candlestick became, as with so many families, a part of Killion lore. A piece of our tribal understanding.

There was the day – a scorching hot afternoon in Mill Valley – when my parents went to a ballgame together. My mother wasn't a huge fan, so it was a notable occasion. Though my mother was a Bay Area native and my father had lived here long enough to understand the winds and weather patterns, they figured it was a perfect day for a ballgame. That game became famous: Willie McCovey's towering flyball dropped for a triple because Dodgers outfielder Duke Snider couldn't see it in the fog. Umpire Frank Dascoli waved the players off the field and delayed the game for 24 minutes. My parents shivered before escaping.

Umpires soon learned there was no strategy that could circumvent the fog. That wasn't the only opinion that became cemented that day.

"Your mother never wanted to go back," my dad told me.

But my dad did. He wasn't a regular. He was content to experience most of his baseball games through the brown transistor radio that resided in his breast pocket throughout baseball season. But he made periodic pilgrimages to both the Giants and the 49ers. He was a loyal San Franciscan: He couldn't believe we were lucky enough to have the world's best baseball player and the best quarterback of all time playing in that windy old ballpark. The dramatic contrast between Candlestick and the athletes that played inside was just one part of the stadium's mystique.

It was with my father that I first experienced the green expanses (which, sadly, I believe was AstroTurf in my earliest memories), towering escalators and chain link outfield fence of Candlestick. Thanks to him, I have faded but real memories of seeing Mays play.

As I grew older, I created my own Stick experience. Sitting with my high school friends in the upper deck, swaddled in puffy down jackets with pockets big enough to hold a flask. Watching the Friday night fights in the stands when the Dodgers were in town. Walking into a 49ers game without tickets, because no one really checked back then when the team was so bad. Sneaking down into the "box seats" – which were regular seats barricaded by metal railings. Very fancy.

Eventually, Candlestick stopped being a location for fun and became a place where I worked. The first time I covered a game at Candlestick, the creaky press elevator and drafty multi-tiered box were mysterious and intriguing, not annoying. The first thing I did when I got settled was to call my father.

"Guess where I am, Dad. In the press box at Candlestick."

My dad responded as if I had said the White House.

"Wow."

Later, we took my parents and their grandkids to games. My father liked sitting on the top deck, looking at the expanse below him. He kept his transistor in his pocket, ate his peanuts and was perfectly content. When the Giants said they were going to move to Florida, I took my father and my young son to say a wistful goodbye, and ensure there was one more moment of family bonding.

But the Giants stayed. And in April 2000, I took my dad on a tour of brand new Pacific Bell Park, days before the season opened. My father was frail and in a wheelchair, but he was overwhelmed by the beauty of the new ballpark. We promised to get to a game in that inaugural year. But a few weeks later Dad fell and broke his leg and his health spiraled downward. That October, not long after the Giants had been eliminated in the playoffs, my father died.

He never made it to a game at the new ballpark. Candlestick was his park, always and forever.

Soon, the concrete will be crumbled by a wrecking ball. But it can't destroy the memories.

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# Sustainability assessment of Low Earth Orbit (LEO) satellite broadband megaconstellations

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## Abstract

The growth of megaconstellations is rapidly increasing the number of rocket launches. While Low Earth Orbit (LEO) broadband satellites help to connect unconnected communities and achieve the Sustainable Development Goals (SDGs), there are also significant environmental emissions impacts from burning rocket fuels. We present sustainability analytics for *phase 1* of the three main LEO constellations including Amazon Kuiper (3,236 satellites), Eutelsat Group's OneWeb (648 satellites), and SpaceX Starlink (4,425 satellites). We find that LEO megaconstellations provide substantially improved broadband speeds for rural and remote communities, but are roughly 6-8 times more emissions intensive (250 kg $CO_2$eq/subscriber/year) than comparative terrestrial mobile broadband. In the worst-case emissions scenario, this rises to 12-14 times more (469 kg $CO_2$eq/subscriber/year). Policy makers must carefully consider the trade-off between connecting unconnected communities to further the SDGs and mitigating the growing space sector environmental footprint, particularly regarding *phase 2* plans to launch an order-of-magnitude more satellites.



## Introduction

The growth in Low Earth Orbit (LEO) satellite broadband constellations involves plans to launch tens of thousands of new satellites into space to provide global broadband coverage. Indeed, LEO constellations are a key reason why the quantity of rocket launches to space has rapidly increased, from fewer than 250 launches annually in the 1970s (below 2,900 per decade), to now exceed 1,300 launches annually (~16,000 in a single decade, more than a 400% increase) [1]. This growing number has resulted in a range of emerging questions around the negative environmental externalities of these satellite megaconstellations [2] and the environmental sustainability aspects of this approach [3], [4], [5], given the increasing commercialization of space activities, from tourism to earth observation.

Indeed, the shift towards ultra-dense satellite megaconstellations, therefore raises new environmental sustainability questions [6], with evidence-based studies indicating projected trends are likely to produce adverse impacts, attracting the attention of regulatory authorities [7]. It is therefore imperative that governments carefully balance the growth of the space sector, and the associated benefits in progressing the Sustainable Development Goals (SDGs), against environmental sustainability issues [8]. To do so, provides strong research motivation for assessing the sustainability implications of launching the large numbers of planned LEO satellites in key megaconstellations. Particularly as the space sector is growing at such a rapid rate as to concern those outside the space community. Evidence is urgently needed to understand negative environmental impacts, to direct mitigation strategies, as evaluated here.

Given this important context, in this paper we develop an integrated model capable of assessing the environmental impacts associated with rocket launches for specific phase 1 LEO constellations, with concurrent metrics on the provided capacity, the Social Cost of Carbon (SCC) and associated cost of delivery. We treat phase 1 of each LEO constellation as the filing information submitted to the US Federal Communications Commission (FCC), such as for Amazon's Kuiper (3,236 satellites), Eutelsat Group's OneWeb (648 satellites) and SpaceX's Starlink (4,425 satellites) [9], [10], [11]. Additionally, a representative Geostationary Earth Orbit (GEO) constellation is appraised for comparison. Currently, within the GEO satellite industry there are a number of major operators such as Intelsat (52 satellites) [12], Eutelsat (35 satellites) [13], Inmarsat (14 satellites) [14], Arabsat (8 satellites) [15], ViaSat (4 satellites) [16] and Avanti (4 satellites) [17]. Here we utilize a representative GEO operator treated as having 19 satellites, representing the mean quantity across these major operators.

Policy makers must consider a key trade-off regarding the SDGs. On the one hand, the delivery of broadband services to unconnected communities is recognized to progress the SDGs. While on the other, the results of this paper demonstrate that the rapid growth in the satellite sector is a pressing issue with substantial environmental sustainability implications. Therefore, this 'space sustainability paradox' [18] means decision-makers must balance the range of economic, social and environmental benefits enabled by improved broadband connectivity, against the growing environmental footprint of the satellite sector.

The method and evidence produced can be used to (i) inform future space sustainability metrics such as the Space Sustainability Rating (SSR) system, and (ii) support strategic future choices in rocket design and fuel options.

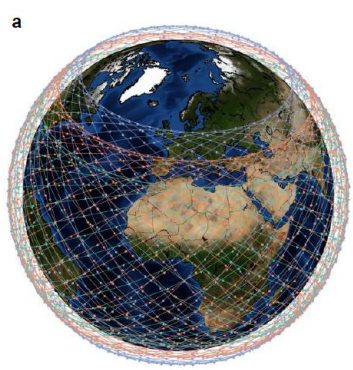


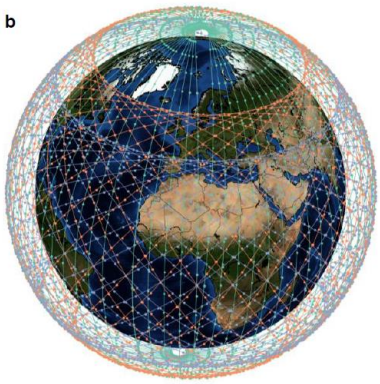
 

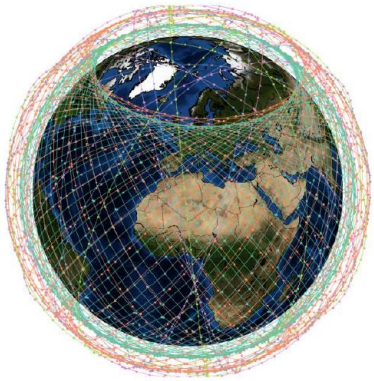
## Current and proposed LEO satellite broadband constellations

In very remote areas, where terrestrial broadband infrastructure is not economically viable due to low population density and/or low adoption, LEO satellites can provide high-capacity, low-latency broadband connectivity to hard-to-reach communities [19], [20]. Importantly, there are key differences when compared to traditional GEO constellations. For example, LEO satellites are designed to be smaller in size, with a shorter lifespan (e.g., 5 years), and are therefore less costly to produce [21]. However, the more proximate orbit to Earth means many more satellites are required to achieve global coverage [22].

That has prompted satellite operators to file for a very large number of satellites in their proposed constellation designs, with the expectation that each constellation will need to be continuously replenished as older satellites end their operational life. For example, in 2022 there were ~6,300 satellites in operation, whereas the total number of proposed satellites over the next decade in new constellations will be as high as ~320,000 [23]. Fig. 1 shows the technical details of three operational and planned LEO constellations assessed in this paper.




d

| | Details |
|---|---|
| *Constellation Name* | Kuiper |
| *Operator* | Amazon |
| *Satellites* | 3,236 |
| *Earth Radius* | 6,378 km |
| *Orbital Altitude* | 610 km |
| *Orbital Radius* | 6,988 km |
| *Path Distance* | 982 km |
| *Satellite Centric Angle* | 48.4 Deg |
| *Earth Centric Angle* | 6.61 Deg |
| *Mean Satellites per Launch* | 36 |
| *Satellites in Orbit (phase 1)* | 2* |

e

| | Details |
|---|---|
| *Constellation Name* | OneWeb |
| *Operator* | Eutelsat |
| *Satellites* | 648 |
| *Earth Radius* | 6,378 km |
| *Orbital Altitude* | 1,200 km |
| *Orbital Radius* | 7,578 km |
| *Path Distance* | 1,580 km |
| *Satellite Centric Angle* | 36.5 Deg |
| *Earth Centric Angle* | 8.48 Deg |
| *Mean Satellites per Launch* | 36 |
| *Satellites in Orbit (phase 1)* | >630 |

f

| | Details |
|---|---|
| *Constellation Name* | Starlink |
| *Operator* | SpaceX |
| *Satellites* | 4,425 |
| *Earth Radius* | 6,378 km |
| *Orbital Altitude* | 550 km |
| *Orbital Radius* | 6,928 km |
| *Path Distance* | 1,123 km |
| *Satellite Centric Angle* | 56.5 Deg |
| *Earth Centric Angle* | 8.45 Deg |
| *Mean Satellites per Launch* | 23 |
| *Satellites in Orbit (Phase 1)* | 4,425 |

**Fig. 1 | Technical details of the constellations as at December, 2023. a,** Amazon's Kuiper is in a testing phase having launched only two prototype satellites (KuiperSat-1 and KuiperSat-2), and are yet to launch any of the planned 3,236 phase 1 satellites (December 2023), **b,** OneWeb has deployed 98% of the 648 phase 1 satellites (December 2023), **c,** SpaceX Starlink has launched 100% of the 4,425 phase 1 satellites [23], [24], [25] (December 2023).



## Life cycle assessment of satellite constellations

Emissions produced during the launching of satellites depend on the rocket vehicle used. Most operators planning or launching LEO broadband satellites have used (or intend to use) SpaceX's Falcon-9 or Falcon-Heavy, the European Space Agency's (ESA's) Ariane, or Russia's Soyuz-FG rocket launch systems. This analysis focuses predominantly on the emissions produced by rocket and propellant manufacturing, transportation, rocket testing and finally launching carried satellite payloads into LEO (and compared to a hypothetical GEO system).

Fig. 2 illustrates these rocket vehicles along with key technical specifications. Depending on the properties of each launch capability, either one or a combination of propellants is utilized, leading to a unique profile of environmental emissions when ignited. Importantly, many compounds are released into the environment, including nitrogen gas, carbon dioxide, carbon monoxide, black carbon, water vapor, hydrogen gas, aluminum oxide, hydrochloric acid and the radicals of chlorate, hydrate and nitrate [3], [26].

| | Falcon-9 | Falcon-Heavy | Soyuz-FG | Ariane-5 |
|---|---|---|---|---|
| *Dry Mass* | 22 tonnes | 66 tonnes | 14 tonnes | 53 tonnes |
| *Operator* | SpaceX | SpaceX | Progress Rocket Space Center | European Space Agency |
| *Payload to LEO* | 23 tonnes | 64 tonnes | 8 tonnes | 20 tonnes |
| *Fuel Type* | Kerosene (Rocket Propellant-1) | Kerosene (Rocket Propellant-1) | Kerosene and Hypergolic | Solid, Hypergolic and Cryogenic |
| *Height* | 70 m | 70 m | 46 m | 46 - 52 m |
| *Price Per Launch* | US$ 62 Million | US$ 90 Million | US$ 80 Million | US$ 149-198 Million |
| *Propellant Mass* | 488 tonnes | 1,397 tonnes | 256 tonnes | 7,645 tonnes |
| *Fuel* | Hydrocarbon | Hydrocarbon | Hydrocarbon | Hydrogen |

**Fig. 2 | Details of the rocket launching vehicles used by LEO constellations.** None of the constellations have hitherto used the Falcon-Heavy rocket. Starlink Phase 2 will likely be launched via Starship, which is still being developed and has substantially different technical details. OneWeb ceased using the Russian Soyuz-FG for launching satellite payloads in 2022. Data sourced from [27], [28], [29].

Quantifying these emissions from rocket launches is complex and not well understood. However, there has been extensive work conducted on approximating the emissions per mass of the fuel burned for the four common propellants used (known as the "mass fraction") [3], [26], [30], [31]. Additional studies have further explored the role of black carbon due to its impact on climate change [32].

Given the differences in constellation size, rocket launch vehicles, quantity of rocket launches, and the provided broadband capacity, each constellation has heterogenous environmental impacts, as reported



here. The impacts are broken down in five categories. Firstly, Global Warming Potential (GWP) defined as the radiative forcing in carbon dioxide equivalents ($CO_2$eq.) over a 100-year horizon by the Intergovernmental Panel on Climate Change [33]. Secondly, Ozone Depletion Potential (ODP) defined by the World Meteorological Organization (WMO) [34] as the steady-state depletion potential in chlorofluorocarbon-11 equivalents (CFC-11eq). Thirdly, Mineral & Metal Resource Depletion Potential defined as the abiotic resource depletion (reserve base) in antimony (Sb) equivalents as implemented by the Centrum voor Milieuwetenschappen (CML) at the University of Leiden [34], [35], [36], and recommended by the ESA Life Cycle Assessment (LCA) Handbook [35]. Fourthly, Freshwater Aquatic Ecotoxicity Potential as the Comparative Toxic Units for ecosystems (CTUe) as implemented in USEtox in potentially affected fraction of species per $m^3$ per day (PAF.$m^3$.day). Finally, Human Toxicity Potential as the Comparative Toxic Units for humans (CTUh), as implemented in USEtox as the estimated increase in morbidity (Cases).

Two emissions scenarios are presented (a baseline and worst-case option) for the launch event in terms of the GWP and ODP categories. The baseline option classifies the exhaust products in accordance with the models applied in this study, as adapted for space applications [26]. Alternatively, the worst-case scenario also includes the potential influence of black carbon, aluminum oxide and water vapor exhaust particles, termed here as Non-normally Included Emissions (NIEs) [37]. The complexity and high uncertainty associated with each of these exhaust products at altitude make them extremely difficult to account for in traditional impact assessment models. As such, they are generally excluded in such models as they are not well-mixed once emitted to the atmosphere because of their very rapid decay. However, it is hypothesized that these could be the most influencing particles from the launch event, therefore it is critical that such impacts are also presented for the GWP and ODP categories, utilizing impact factors from aviation [31]. See the Supplementary Information for a comprehensive overview on the developed method.

## LEO constellations have large and growing environmental impacts

Different rocket combinations have been or will be used to launch upcoming satellite constellations, as detailed in Fig. 3a. Currently, Starlink has made 127 launches to place all its 4,425 satellites in orbit using Falcon-9 a hydrocarbon (HYC) fuel-based rocket. Similarly, OneWeb placed 96 of its satellites in 3 launches with Falcon-9, while the remaining were made on India's LVM3 (2 launches for 72 satellites) (HYD) and Russian Soyuz-FG (14 launches for 394 satellites) (HYC). For Kuiper, Amazon has announced the majority of their future launches, including 38 via United Launch Alliance's Vulcan Centaur rocket (HYC), 18 via Arianespace's Ariane-6 hydrogen (HYD) rocket, up to 27 via Blue Origin's New Glenn (HYC) rocket, and 3 via Falcon-9 [38]. We split the remaining 4 between generic hydrocarbon (HYC) and generic hydrogen (HYD) rockets. Finally, for the hypothetical GEO operator, we model 10 launches via HYC and 9 launches via HYD (with one satellite per launch).

The resulting annual emissions per subscriber (in kg $CO_2$eq) are illustrated in Fig. 3b. Environmental impacts are commonly reported by subscriber for telecommunication networks annually [39], [40], [41]. This is an essential way to provide decision makers with an understanding of system impacts, while accounting for (i) the quantity of users receiving service, and (ii) different asset lifetimes [42]. Publicly available subscriber data [43], [44] are utilized to account for the low, baseline and high adoption scenarios, as detailed in the methodology and Supplementary Information (SI). This baseline includes 2.5 million future subscribers for



Kuiper (0 currently), 0.8 million for OneWeb (about 0.2 million currently), 3.5 million for Starlink (2.2 million currently), and 2.5 million for the representative GEO operator. Consequently, estimated annual baseline emissions correspond to 303±131 kg $CO_2$eq/subscriber for Kuiper, 274±101 kg $CO_2$eq/subscriber for OneWeb, 172±51 kg $CO_2$eq/subscriber for Starlink, and 21±9 kg $CO_2$eq/subscriber for GEO. Thus, on average the subscriber emissions from LEO constellations are more than 12 times higher than the representative GEO operator. However, in the worst-case emissions scenario these values increase to 617±268 kg $CO_2$eq/subscriber for Kuiper, 418±154 kg for $CO_2$eq/subscriber for OneWeb, and 373±111 kg $CO_2$eq/subscriber for Starlink. This compares to 55±24 kg $CO_2$eq/subscriber for GEO, indicating LEO produces approximately 8 times more emissions, when accounting for NIEs.

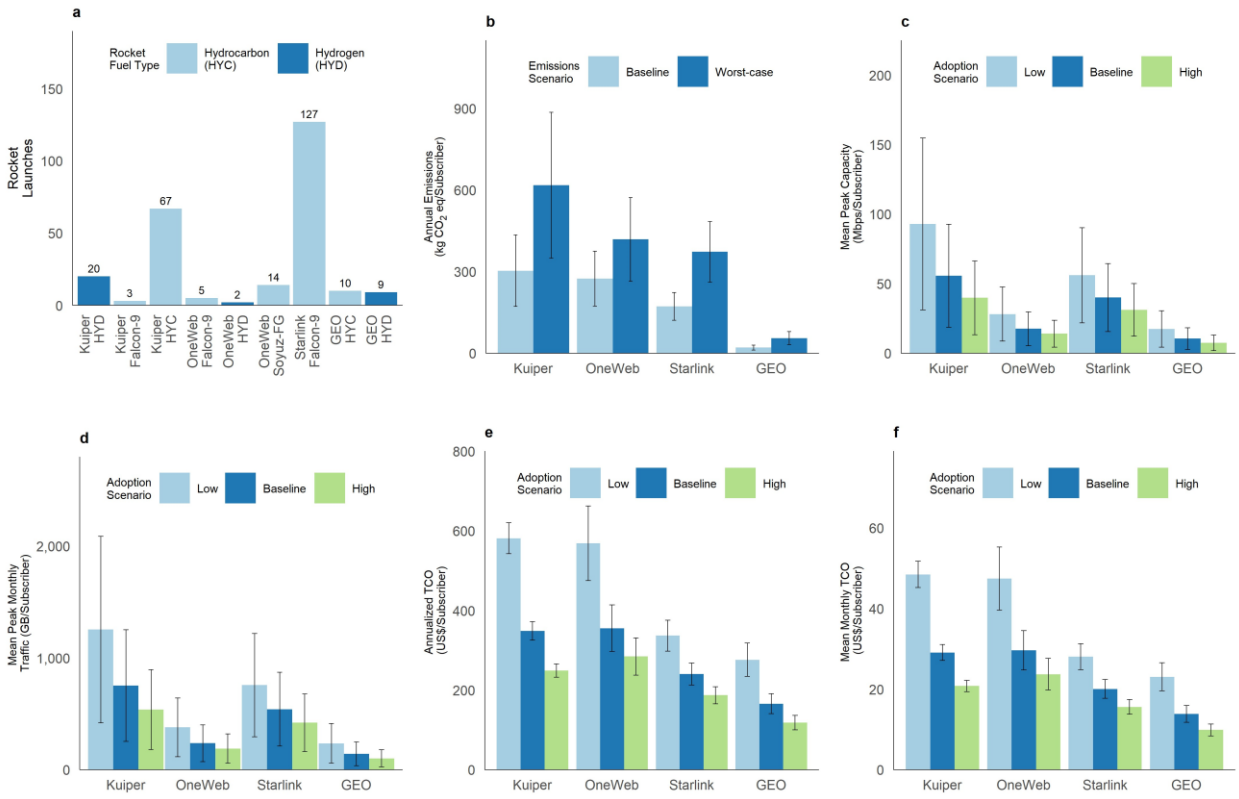



**Fig. 3 | Constellation Metrics. a,** Quantity of rocket launches by constellation and rocket fuel-type, based on information as of December 2023. We use generic hydrogen (HYD) and hydrocarbon (HYC) rocket vehicles when the exact launcher is not in the SSSD database or the rocket type is unknown (via a 50-50 split). In total for this evaluation, 63% of assessed LEO launches are based on a modeled rocket, 36% utilize a generic rocket for a known launcher, and only 2% utilize a generic rocket for an unknown launcher. **b,** Equivalent annual emissions estimated per subscriber for each constellation, given the baseline versus the worst-case emissions outcome, with Confidence Intervals (CIs) representing low and high subscriber adoption scenarios, **c,** The estimated mean provided peak data rate with CIs representing 1 Standard Deviation (SD) in mean capacity for each adoption scenario, **d,** Potential peak monthly traffic per subscriber estimated with CIs representing 1 SD in monthly traffic for each adoption scenario, **e,** The estimated



annualized Total Cost of Ownership (TCO) per subscriber by constellation with CIs representing 1 SD in TCO for each adoption scenario, **f,** The estimated average monthly TCO per subscriber with CIs representing 1 SD for each adoption scenario.

Importantly, LEO constellations are aiming to serve hard-to-reach locations in rural and remote areas, where terrestrial broadband infrastructure deployment is unviable. Evaluation of operational carbon emissions suggests annual emissions intensities of 32.8 kg $CO_2$eq/subscriber in rural areas, and 39.5 kg $CO_2$eq/subscriber in remote areas [41] for terrestrial mobile broadband (4G). Therefore, furthering the results visualized in Fig. 3b, this means that compared to terrestrial mobile broadband, LEO is approximately 8 times higher per rural subscriber, or 6 times higher per remote subscriber, in the baseline emissions scenario. In contrast, GEO emissions of 22 kg $CO_2$eq/subscriber are nearly one third lower for rural subscribers, and nearly 50% lower for remote subscribers, for terrestrial mobile broadband (4G). However, the worst-case emissions scenario changes substantially. LEO is approximately 14 times higher for rural subscribers, compared to 12 times higher for remote subscribers, when compared to terrestrial mobile broadband. These values compare to mean annual emissions for terrestrial European Mobile Network Operators (MNOs) (using 2G-4G) of 6.6 kg $CO_2$eq/subscriber (across urban and rural subscribers) [45].

Results are reported in Fig. 4, broken down by HYC and HYD rockets over each constellation lifetime. Baseline carbon emissions are visualized (Fig. 4a) alongside worst-case emissions which include NIEs (black carbon, aluminum oxide and water vapor) (Fig. 4b). The results suggest that climate change emissions account for one of the highest proportions of LCA effects. For example, for HYC the full launch of the planned Kuiper constellation in the baseline emissions scenario is estimated to produce 2.71 Mt $CO_2$eq, versus 0.9 Mt $CO_2$eq for OneWeb, 2.84 Mt $CO_2$eq for Starlink and 0.39 Mt $CO_2$eq for GEO as illustrated in Fig. 4a. Whereas, the associated emissions for the HYD portion are comparatively lower for Kuiper (0.65 Mt $CO_2$eq), OneWeb (0.07 Mt $CO_2$eq) and GEO (0.29 Mt $CO_2$eq).

Considering the HYC rocket in the worst-case scenario, Kuiper is associated with 4.05 Mt $CO_2$eq, compared to OneWeb at 1.2 Mt $CO_2$eq, Starlink at 6.16 Mt $CO_2$eq and GEO at 0.58 Mt $CO_2$eq (Fig. 4b). In the case of a HYD rocket, Kuiper is associated with 2.79 Mt $CO_2$eq, compared to 0.28 Mt $CO_2$eq for OneWeb and 1.26 Mt $CO_2$eq for GEO. For comparison, terrestrial European MNOs (2G-4G) reported annual emissions of approximately 3.4 Mt in 2018 [45] for 401 million subscriptions (highlighting the need to consider metrics on a per subscriber basis, as presented in Fig. 3b). See the Supplementary Information lifecycle assessment results section for further review of all metrics.



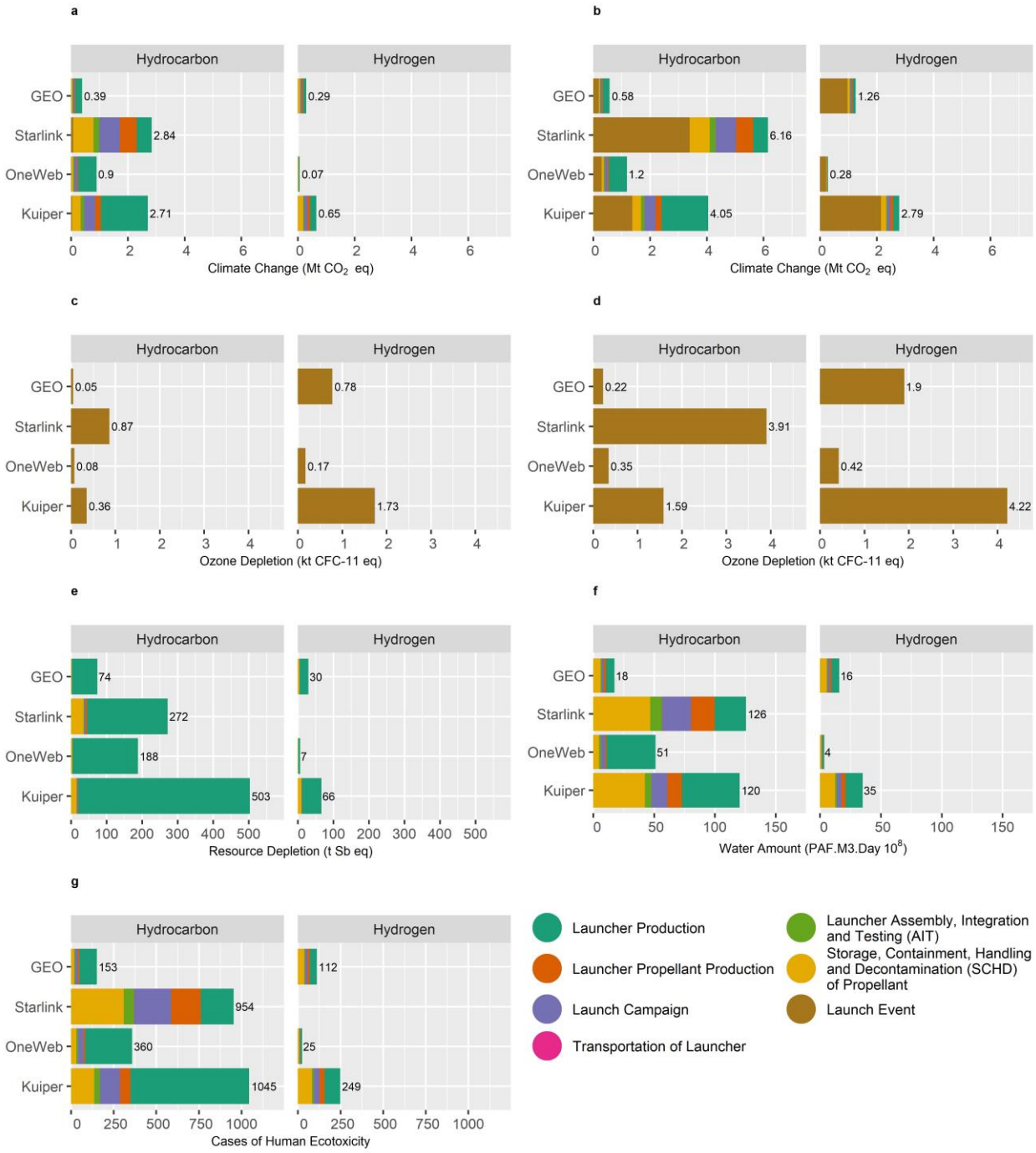



**Fig. 4 | Key constellations by environmental impact category.** **a**, Climate change impacts (baseline), **b,** Climate change impacts including NIEs (worst-case), **c,** Ozone depletion (baseline), **d,** Ozone depletion including NIEs (worst-case), **e,** Resource depletion, **f,** Freshwater ecotoxicity, **g,** Human toxicity.

## The Social Cost of Carbon (SCC) for different satellite systems

The SCC measures the monetary value of damages to society caused by emitting an incremental ton of $CO_2$ or its equivalents over this unit's lifetime in the atmosphere [46]. This approach is used in conducting cost-benefit analysis of policies which may have sustainability impacts (often required by regulatory agencies) [47]. Monetization via SCC enables assessment of sustainability and economic impacts in common units, and does not represent legal claims. Here, we estimate the SCC for the two emissions scenarios associated with phase 1 of each constellation, as illustrated in Fig. 5.

Firstly, the total social cost in the baseline emissions scenario is estimated at $621 million for Kuiper, versus $179 million for OneWeb, $526 million for Starlink and $127 million for a representative GEO operator (Fig. 5a). In contrast, for the worst-case emissions scenario the social cost of Kuiper is estimated at $1.3 billion, versus $273 million for OneWeb, $1.1 billion for Starlink and $341 million for a GEO operator (Fig. 5b).

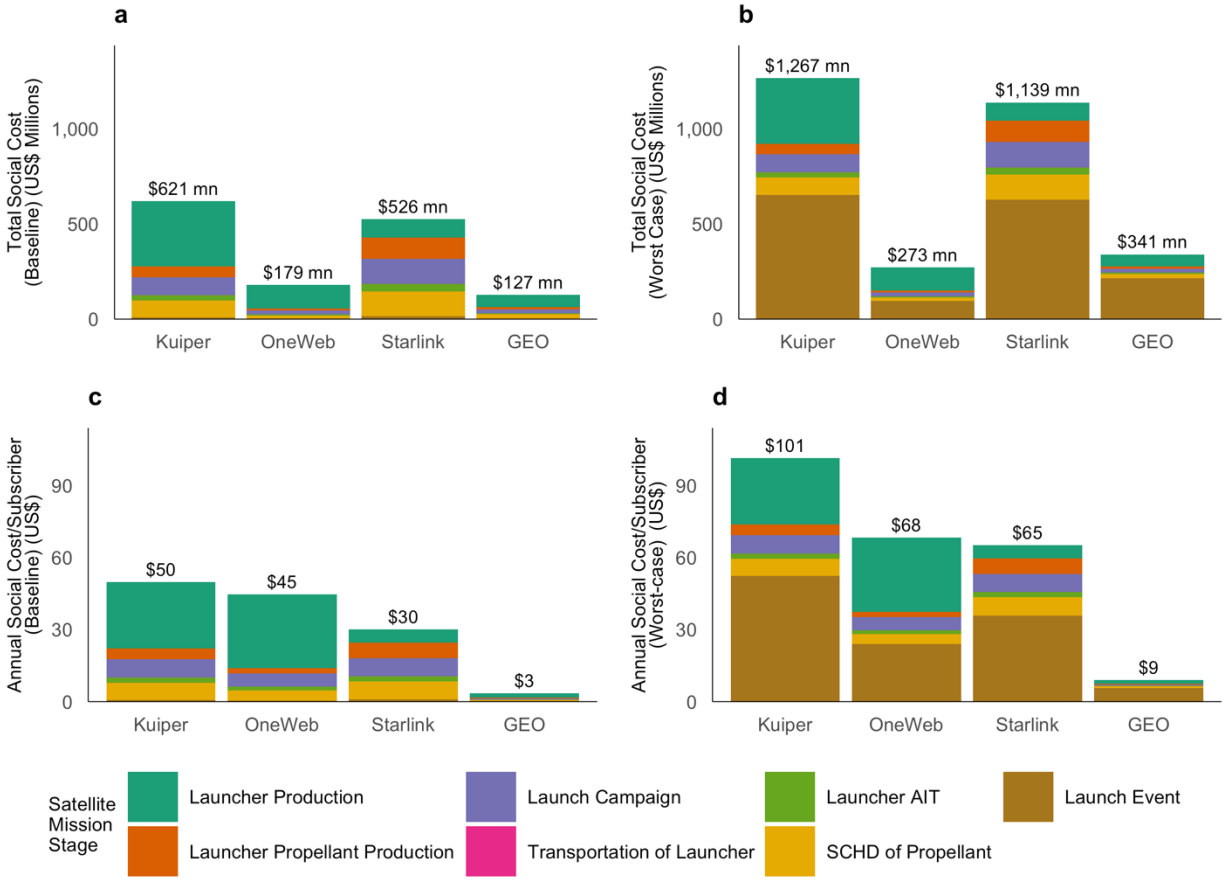



**Fig. 5 | Social cost of carbon. a,** The total SCC of the emissions baseline over a five (LEO) and fifteen (GEO)-year time horizon, **b,** The total SCC of the emissions worst-case, **c,** The Annualized SCC per subscriber for the emissions baseline, **d,** The Annualized SCC per subscriber for the emissions worst-case over the time horizon.

Secondly, it is imperative that these estimates are broken down by the number of subscribers expected to be served by each constellation annually. For example, the per subscriber social cost is estimated to be $50



for Kuiper in the baseline emissions and adoption scenarios, versus $45 for OneWeb, $30 for Starlink and $3 for GEO operator (Fig. 5c). In contrast, when accounting for the worst-case emissions scenario, the estimated annual social cost per Kuiper subscriber is $101, versus $68 for OneWeb, $65 for Starlink and $9 for the GEO operator (Fig. 5c).

## Policy implications

The results presented demonstrate that the phase 1 LEO constellations currently being deployed have significant sustainability implications, with these impacts likely to substantially increase as the sector aims to move to constellations an order-of-magnitude larger over the next decade (from thousands of satellites to tens of thousands). Hitherto, the space sector has largely operated and been regulated under the premise that launch traffic and operational intensity would be low enough to minimize environmental impacts [34], [48]. Our analysis shows this assumption is breaking down in the era of megaconstellations, given the thousands of planned satellite assets requiring frequent rocket launches to reach orbit.

Indeed, phase 1 LEO constellations have annual operational environmental footprints under the baseline emissions scenario (0.2-0.7 Mt $CO_2$eq) equivalent to the energy usage of 24-85k annual US homes or 43-150k annual gasoline-powered passenger vehicles. In the worst-case scenario (0.3-1.4 Mt $CO_2$eq), this rises to operational environmental footprints equivalent to the energy usage from 37–173k annual US homes, or 66-305k annual gasoline-powered passenger vehicles. The GEO network modeled with total annual emissions of 0.4 Mt $CO_2$eq in the worst-base, is comparable to the energy usage of 46k annual US homes, or 82k annual gasoline-powered passenger vehicles [49].

In contrast, the annual subscriber environmental footprints for LEO (172-303 kg $CO_2$eq) are equivalent to a one-way economy-class flight between London and Milan (257 kg $CO_2$eq) (900 km). Rising in the worst-case scenario (373-617 kg $CO_2$eq) to almost equivalent of a one-way economy-class flight between New York and San Francisco (713 kg $CO_2$eq) (4,200 km) (under baseline emissions and adoption scenarios). While improvements in launcher designs and transportation logistics may reduce this footprint, the coming rush of large LEO constellations suggests the total environmental footprint of the space sector is likely to rise regardless (particularly as this assessment did not include a range of other growing space activities, such as tourism). The comparative GEO constellation had relatively modest annual emissions impacts ranging from 21-55 kg $CO_2$eq/subscriber, similar in the baseline to driving from Florence to Bologna (117 km), or in the worst-case scenario driving from Florence to Rome (273 km).

Much of the focus on LEO megaconstellation hitherto has been regarding orbital debris and changes to the night sky [50]. Those impacts are not generally covered under existing environmental policies and international agreements. By contrast, the environmental sustainability impacts we measure here are not novel *per se*, so are better represented in existing environmental policy. While $CO_2$ emissions may not be covered under binding international agreements, they are recognized under existing legal structures, e.g., the Paris Agreement. Certainly, further research on life cycle impacts of satellite constellations is needed to clarify their implications for existing environmental agreements and targets.



How might these responsibilities be carried out? Broadly, there are two paths: targeting launches within a covered jurisdiction directly, or targeting services provided to subscribers. While some concerns may exist regarding polluting launchers fleeing to jurisdictions with laxer regulations (i.e. “launch leakage”), some prior analyses of environmental regulations have found relatively low levels of leakage [51]. The magnitude of this effect in the space sector is an important open empirical question. Where targeting launchers is infeasible or not currently taking place, existing border carbon adjustment policies offer an example of a potential policy response [52], [53], [54], [55]. By pricing emissions at the point of service delivery, national actors – particularly those with large or lucrative domestic markets – can partially offset the incentive to flee to so-called “pollution havens”.

Environmental policies will likely impose costs on the space industry. Some of these costs will be passed on to service subscribers, reducing service availability for those who need broadband, and would benefit from progressing the SDGs. Our LEO calculations, combined with recent SCC estimates [56], suggest the efficient carbon price necessary to induce the systems to internalize these externalities is on the order of US$ 179–621 million, equating to an incremental US$ 30–50 per subscriber annually (given estimated subscriber costs, $185 per tonne of carbon, and plausible demand scenarios). However, when including NIEs these estimates increase under the worst-case emissions scenario to US$ 0.3–1.3 billion, equating to US$ 65–101 per subscriber annually.

These carbon prices offer useful guidance on the magnitude of the externalities these systems generate. Balancing the management of these externalities against the social benefits of greater broadband access is a challenging task requiring further development of integrated modeling frameworks as presented here.

## Conclusions

This assessment finds that LEO constellations provide substantial capacity improvements in the broadband services rural and remote communities can access. However, this comes at a price, as emissions from LEO constellations are quite considerably higher compared to serving rural and remote communities via terrestrial mobile networks, based on the plausible demand scenarios evaluated. For example, on average in the baseline emissions scenario, launching broadband LEO constellations results in 250 kg $CO_2$eq/subscriber annually, roughly 6-8 times higher than values for terrestrial mobile networks (with comparative values of 32.8 kg $CO_2$eq per rural subscriber and 39.5 kg $CO_2$eq per remote subscriber). Indeed, in the worst-case emissions scenario, we find that on average LEO constellations incur 469 kg $CO_2$eq/subscriber annually, roughly 12-14 times worse than terrestrial mobile broadband. Whereas the representative GEO constellation modeled was only up to 1.7 times worse annually (55 kg $CO_2$eq/subscriber).

Secondly, we find that compared to a representative GEO constellation, LEO constellations are approximately 9-12 times more emissions intensive, depending on the emissions scenario. For example, GEO incurs approximately 21-55 kg $CO_2$eq/subscriber, which are within the same order-of-magnitude as serving rural and remote subscribers via terrestrial mobile broadband (4G). In contrast though, the mean peak capacity provided by LEO constellations is on average four times higher under the plausible baseline



demand scenario (11 Mbps/subscriber for GEO versus 39 Mbps/subscriber for LEO, if all users simultaneously access the network).

Currently, this study only focuses on phase 1 of Amazon Kuiper, OneWeb and SpaceX Starlink, while the planned phase 2 constellations are an order-of-magnitude larger, raising the need for greater consideration of space sector environmental impacts and future research on quantifying phase 2 emissions. Indeed, space companies and regulators require comprehensive sustainability analytics, as presented here, to inform mitigation efforts capable of balancing environmental effects, provided broadband capacity, social costs and other financial considerations. It would also be beneficial for more research to (i) reduce and quantify uncertainty in emissions estimates, especially for ozone, and (ii) to help estimate emissions impacts from re-entry particles.

It is important to note, however, that a wide range of benefits are achieved by helping unconnected communities gain access to a broadband connection, with positive impacts across the SDGs. Therefore, policy decisions require deep consideration of this trade-off. Certainly, emissions increases will take place, as quantified here. Yet, there will be wider socio-economic benefits too. Further research should consider quantifying the sustainability impacts of broadband, particularly for emissions reduction and abatement strategies (e.g., utilizing smartphones).

## Method

To assess the sustainability implications of different LEO megaconstellations, we developed the open-source Sustainability Analytics for Low Earth Orbit Satellites (Saleos) codebase. In this method, we describe each step in the Saleos modeling process taken to estimate the incurred environmental sustainability impacts, provided capacity, potential demand, and associated social and financial costs, applied here to the three main LEO constellations (as well as a comparable GEO constellation). This integrated modeling approach is detailed further in the Supplementary Information, demonstrating how each of these steps fit together, given the salient exogenous and endogenous model variables used to produce the results.

### Life Cycle Assessment

A process-based LCA is utilized to quantify the environmental impacts associated with delivering the necessary satellites to complete each phase 1 LEO constellation. LCA is a technique used to model the environmental impacts of a process, product, or service over their entire life cycle, from raw material extraction through to the end of lifetime of each asset (internationally standardized via ISO 14040 [57] and ISO 14044 [58]). The process-based approach is centered on scientifically analyzing specific activities (i.e., mass/material balance, scientific characteristics, etc.) and linking these to a functional unit. A functional unit describes the quantity of a product or product system based on the performance it delivers in its end-use application. In this case, the functional unit refers to the total number of launches required to place all proposed satellites within each constellation into their desired orbit. The activities accounted for under this functional unit are determined based on the system boundary in the Supplementary Information.

The data on production of different rockets used for launching satellites are sourced from the Strathclyde Space Systems Database (SSSD). The SSSD has a variety of datasets on the production of different launchers,



including Falcon-9, Ariane, and Soyuz-FG, carefully formed based on freely available industry data and interviews with a variety of relevant industrial stakeholders. We use generic hydrogen (HYD) and hydrocarbon (HYC) rocket vehicles when the exact launcher is not in the SSSD database or the rocket type is unknown. These generic rockets use mean values produced from fully modeled launchers within the SSSD. In total for this evaluation, 63% of assessed LEO launches are based on a modeled rocket, 36% utilize a generic rocket for a known launcher, and only 2% utilize a generic rocket for an unknown launcher. A similar approach is utilized for GEO. The Supplementary Information specifies the full LCA method.

## Provided capacity

The downlink channel capacity of each LEO constellation is estimated as this is generally the main bottleneck for subscribers trying to access online content. To do this, the Friss Transmission equation is utilized, as detailed in the Supplementary Information, following an established methodology [59], [60], [61], [62], [63], [64]. Firstly, information is gathered on antenna characteristics and then used to estimate the energy per bit to noise power spectral density ratio $\left(\frac{E_b}{N_O}\right)_{dB}$. Based on FCC filings, the channel capacity is calculated from the modulation coding schemes and spectral efficiency values, with the expectation that next generation satellites are likely to use Adaptive Coding and Modulation (ACM). Next, the total satellite capacity (in Mbps) is obtained, by multiplying the channel capacity by the number of beams and channels. Finally, the total usable constellation capacity is estimated by multiplying the total satellite capacity, by the number of satellites in each constellation, along with a factor which represents the average percentage time each satellite spends over land serving subscribers (as opposed to generally idle over ocean).

## Potential demand

We develop scenarios of future change which capture demand uncertainty in adoption. Estimating future demand is a key challenge when evaluating sustainability aspects of infrastructure systems *[65]*, raising the need for scenarios, given the lack of available robust scientific information for modeling. Information is gathered on the current number of LEO broadband subscribers by Q4 2022, and is generally used as the low adoption scenario (e.g., no further adoption). As detailed thoroughly in the Supplementary Information, the baseline and high adoption scenarios see the existing customer base broadly increase by 1.5x and 2x, respectively, following industry information. The estimated data rate capacity per subscriber (Mbps) can then be obtained, by dividing the total usable capacity with the number of subscribers in each scenario. Finally, the maximum quantity of data traffic, which this capacity can enable each subscriber to download per month, is estimated (in GB/Month).

## Costs

Both the social and financial costs associated with launching phase 1 of each LEO constellation are estimated following [21] and *[66]*, as detailed in the Supplementary Information. Firstly, the total climate change emissions (the GWP) associated with each LEO constellation is multiplied by the social cost of a single tonne of carbon as established in *[56]*, to obtain the SCC. Then the lifetime total capital expenditure (capex) is evaluated when considering the costs of satellite manufacturing, satellite launch, ground station investment, and fiber infrastructure. Next, the lifetime total operational expenditure is evaluated when considering the recurring costs of ground station energy consumption, staff labor, regulatory fees, subscriber acquisition, and maintenance. Finally, the TCO is obtained by summing all initial capital



expenditure costs, and recurring annual operational expenditure, discounted at a rate of 7% based on the Cost of Capital *[67]* over the lifetime of each LEO/GEO constellation. To normalize for different lifetimes, metrics are converted to either annual or monthly quantities.

## Limitations

We identify three key methodological limitations. The first limitation relates to the uncertainties present within the environmental modeling emissions factors, as there is still considerable scientific research to be undertaken to better understand and quantify the differences between the baseline and worst-case emissions scenarios. Should new emissions factors emerge, the open-source codebase could be readily utilized to re-assess the implications with regards to LEO constellations. The second methodological limitation relates to the wider estimation of the environmental impacts of LEO, as the system boundary utilized had a notable exclusion in the form of the production, development and testing of spacecraft. The reason this was excluded from the study is because no LCI data for this activity could be found for Amazon Kuiper, OneWeb or SpaceX Starlink, including either a list of components or bill of materials. In the future, it would be beneficial for this analysis to be revisited should such information later become publicly accessible. Finally, the capacity estimates reported here have only focused on the downlink channel as this is frequently the main bottleneck in wireless broadband networks. However, future research should explore how both the downlink and uplink capacity of the networks could be integrated, should better information become available on ground stations, inter-satellite links etc.

## Code availability

The code used in the Sustainability Analytics for Low Earth Orbit Satellites (saleos) is available at https://github.com/Bonface-Osoro/saleos. The repository model code is written in Python with visualization scripts produced in R. The repository code contains input data that users can customize or replace with their bespoke values to produce new results for similar systems.

## Data availability

All data are deposited in the associated zenodo data repository at https://zenodo.org/record/8102102.

## References

[1] Our World in Data, “Number of payloads and rocket bodies in space, by orbit,” Our World in Data. Accessed: May 31, 2023. [Online]. Available: https://ourworldindata.org/grapher/space-objects-by-orbit

[2] A. Witze, “2022 was a record year for space launches,” *Nature*, vol. 613, no. 7944, pp. 426–426, Jan. 2023, doi: 10.1038/d41586-023-00048-7.

[3] M. Ross, M. Mills, and D. Toohey, “Potential climate impact of black carbon emitted by rockets,” *Geophys. Res. Lett.*, vol. 37, no. 24, 2010, doi: 10.1029/2010GL044548.

[4] L. Miraux, A. R. Wilson, and G. J. Dominguez Calabuig, “Environmental sustainability of future proposed space activities,” *Acta Astronaut.*, vol. 200, pp. 329–346, Nov. 2022, doi: 10.1016/j.actaastro.2022.07.034.

[5] A. Lawrence *et al.*, “The case for space environmentalism,” *Nat. Astron.*, vol. 6, no. 4, Art. no. 4, Apr. 2022, doi: 10.1038/s41550-022-01655-6.

[6] J. A. Dallas, S. Raval, J. P. Alvarez Gaitan, S. Saydam, and A. G. Dempster, “The environmental impact of emissions from space launches: A comprehensive review,” *J. Clean. Prod.*, vol. 255, p. 120209, May 2020, doi: 10.1016/j.jclepro.2020.120209.



[7] L. Miraux, "Environmental limits to the space sector's growth," *Sci. Total Environ.*, vol. 806, p. 150862, Feb. 2022, doi: 10.1016/j.scitotenv.2021.150862.
[8] A. R. Wilson, M. Vasile, C. A. Maddock, and K. J. Baker, "Ecospheric life cycle impacts of annual global space activities," *Sci. Total Environ.*, vol. 834, p. 155305, Aug. 2022, doi: 10.1016/j.scitotenv.2022.155305.
[9] Federal Communications Commission, "OneWeb FCC Filing," vol. FCC 17-77, 2018, [Online]. Available: https://docs.fcc.gov/public/attachments/FCC-17-77A1.pdf
[10] Federal Communications Commission, "SpaceX FCC Filing," vol. FCC 18-38, 2018. [Online]. Available: https://docs.fcc.gov/public/attachments/FCC-18-38A1.pdf
[11] Federal Communications Commission, "Kuiper Systems LLC FCC Filing," 2020. [Online]. Available: https://docs.fcc.gov/public/attachments/FCC-20-102A1.pdf
[12] Intelsat Ltd, "Satellite Flight Operations and Engineering | Intelsat." Accessed: Jan. 15, 2024. [Online]. Available: https://www.intelsat.com/space/products/satellite-operations/
[13] "Our Company | Eutelsat." Accessed: Feb. 19, 2024. [Online]. Available: https://www.eutelsat.com
[14] "Global coverage. Infinite connections.," Inmarsat Corporate Website. Accessed: Feb. 19, 2024. [Online]. Available: https://www.inmarsat.com/en/about/technology/satellites.html
[15] "The Arabsat Fleet," Arabsat. Accessed: Feb. 19, 2024. [Online]. Available: https://www.arabsat.com/the-fleet/
[16] "An entire world of customers relies on Viasat satellites," viasat.com. Accessed: Feb. 19, 2024. [Online]. Available: https://news.viasat.com/blog/corporate/an-entire-world-of-customers-relies-on-viasat-satellites
[17] "Our Fleet of Satellites," Avanti Communications. Accessed: Feb. 19, 2024. [Online]. Available: https://www.avanti.space/technology/satellites/
[18] A. R. Wilson and M. Vasile, "The space sustainability paradox," *J. Clean. Prod.*, vol. 423, p. 138869, Oct. 2023, doi: 10.1016/j.jclepro.2023.138869.
[19] T. Ahmmed, A. Alidadi, Z. Zhang, A. U. Chaudhry, and H. Yanikomeroglu, "The Digital Divide in Canada and the Role of LEO Satellites in Bridging the Gap," 2022, doi: 10.13140/RG.2.2.18223.20648.
[20] I. del Portillo, S. Eiskowitz, E. F. Crawley, and B. G. Cameron, "Connecting the other half: Exploring options for the 50% of the population unconnected to the internet," *Telecommun. Policy*, vol. 45, no. 3, p. 102092, Apr. 2021, doi: 10.1016/j.telpol.2020.102092.
[21] O. B. Osoro and E. J. Oughton, "A Techno-Economic Framework for Satellite Networks Applied to Low Earth Orbit Constellations: Assessing Starlink, OneWeb and Kuiper," *IEEE Access*, vol. 9, pp. 141611–141625, 2021, doi: 10.1109/ACCESS.2021.3119634.
[22] G. Maral, M. Bousquet, and Z. Sun, *Satellite Communications Systems: Systems, Techniques and Technology*. John Wiley & Sons, 2020.
[23] Federal Communication Commission, "FCC Grants SpaceX's Satellite Broadband Modification Application," Federal Communications Commission. Accessed: Sep. 14, 2022. [Online]. Available: https://www.fcc.gov/document/fcc-grants-spacexs-satellite-broadband-modification-application
[24] Federal Communications Commission, "FCC Grants OneWeb US Access for Broadband Satellite Constellation," Federal Communications Commission. Accessed: Sep. 14, 2022. [Online]. Available: https://www.fcc.gov/document/fcc-grants-oneweb-us-access-broadband-satellite-constellation
[25] Federal Communications Commission, "FCC Authorizes Kuiper Satellite Constellation," Federal Communications Commission. Accessed: Sep. 14, 2022. [Online]. Available: https://www.fcc.gov/document/fcc-authorizes-kuiper-satellite-constellation
[26] A. R. Wilson, "Advanced methods of life cycle assessment for space systems."
[27] SpaceX LLC, "Falcon User's Guide." spacex.com. [Online]. Available: https://www.spacex.com/media/falcon-users-guide-2021-09.pdf



[28] A. Zak, “Soyuz-FG’s long road to retirement.” Accessed: Sep. 14, 2022. [Online]. Available: https://www.russianspaceweb.com/soyuz-fg.html
[29] ArianneSpace Group, “Ariane 5: The Heavy Launcher,” Arianespace. Accessed: Sep. 14, 2022. [Online]. Available: https://www.arianespace.com/vehicle/ariane-5/
[30] M. Ross, D. Toohey, M. Peinemann, and P. Ross, “Limits on the Space Launch Market Related to Stratospheric Ozone Depletion,” *Astropolitics*, vol. 7, no. 1, pp. 50–82, Mar. 2009, doi: 10.1080/14777620902768867.
[31] M. N. Ross and P. M. Sheaffer, “Radiative forcing caused by rocket engine emissions,” *Earths Future*, vol. 2, no. 4, pp. 177–196, 2014, doi: 10.1002/2013EF000160.
[32] G. J. Dominguez Calabuig, L. Miraux, A. Wilson, A. Pasini, and A. Sarritzu, *Eco-design of future reusable launchers: insight into their life cycle and atmospheric impact*. 2022. doi: 10.13009/EUCASS2022-7353.
[33] G. Myhre *et al.*, “Anthropogenic and Natural Radiative Forcing,” *Clim. Change 2013 Phys. Sci. Basis Contrib. Work. Group Fifth Assess. Rep. Intergov. Panel Clim. Change*, 2013.
[34] World Meteorological Organization (WMO), “Scientific Assessment of Ozone Depletion: 2022,” Geneva, GAW Report No. 278, 2022.
[35] J. B. Guinée *et al.*, *Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards, Dordrecht, Netherlands: Series: Eco-efficiency in industry and science*. Dordrecht, Netherlands: Kluwer Academic Publishers, 2022. Accessed: Jun. 07, 2023. [Online]. Available: https://www.universiteitleiden.nl/en/research/research-projects/science/cml-new-dutch-lca-guide
[36] L. van Oers, A. de Koning, J. B. Guinée, and G. Huppes, “Abiotic resource depletion in LCA-Improving characterisation factors for abiotic resource depletion as recommended in the new Dutch LCA Handbook,” Road and Hydraulic Engineering Institute, 2002, 2002.
[37] L. Casalino, A. Ferrero, F. Masseni, and D. Pastrone, “Emission-Driven Hybrid Rocket Engine Optimization for Small Launchers,” *Aerospace*, vol. 9, no. 12, Art. no. 12, Dec. 2022, doi: 10.3390/aerospace9120807.
[38] Amazon, “Amazon secures 3 launches with SpaceX to support Project Kuiper deployment,” US About Amazon. Accessed: Feb. 28, 2024. [Online]. Available: https://www.aboutamazon.com/news/innovation-at-amazon/amazon-project-kuiper-spacex-launch
[39] D. Lundén, J. Malmodin, P. Bergmark, and N. Lövehagen, “Electricity Consumption and Operational Carbon Emissions of European Telecom Network Operators,” *Sustainability*, vol. 14, no. 5, Art. no. 5, Jan. 2022, doi: 10.3390/su14052637.
[40] J. Malmodin, N. Lövehagen, P. Bergmark, and D. Lundén, “ICT sector electricity consumption and greenhouse gas emissions – 2020 outcome,” *Telecommun. Policy*, p. 102701, Jan. 2024, doi: 10.1016/j.telpol.2023.102701.
[41] D. Ruiz *et al.*, “Life cycle inventory and carbon footprint assessment of wireless ICT networks for six demographic areas,” *Resour. Conserv. Recycl.*, vol. 176, p. 105951, Jan. 2022, doi: 10.1016/j.resconrec.2021.105951.
[42] A. Kelly and C. Comendant, “Assessing the emissions footprint of the fibre networks relative to other fixed broadband options in New Zealand,” Auckland, Technical Report, 2021. Accessed: Jan. 24, 2024. [Online]. Available: https://srgexpert.com/2023/08/29/the-emissions-footprint-of-broadband-in-new-zealand/
[43] R. Jewett, “SpaceX Starlink Internet Service Surpasses 1M Subscribers,” Via Satellite. Accessed: Jun. 05, 2023. [Online]. Available: https://www.satellitetoday.com/broadband/2022/12/19/spacex-starlink-internet-service-surpasses-1m-subscribers/
[44] M. Sheetz, “SpaceX’s Starlink satellite internet surpasses 400,000 subscribers globally,” CNBC. Accessed: Jun. 08, 2023. [Online]. Available: https://www.cnbc.com/2022/05/25/spacexs-starlink-surpasses-400000-subscribers-globally.html



[45] D. Lundén, J. Malmodin, P. Bergmark, and N. Lövehagen, "Electricity Consumption and Operational Carbon Emissions of European Telecom Network Operators," *Sustainability*, vol. 14, no. 5, Art. no. 5, Jan. 2022, doi: 10.3390/su14052637.
[46] K. Rennert *et al.*, "Comprehensive evidence implies a higher social cost of CO2," *Nature*, vol. 610, no. 7933, Art. no. 7933, Oct. 2022, doi: 10.1038/s41586-022-05224-9.
[47] U. S. Government Accountability Office, "Social Cost of Carbon: Identifying a Federal Entity to Address the National Academies' Recommendations Could Strengthen Regulatory Analysis | U.S. GAO." Accessed: Jan. 05, 2024. [Online]. Available: https://www.gao.gov/products/gao-20-254
[48] A. Q. Gilbert and M. Vidaurri, "Major Federal Actions Significantly Affecting the Quality of the Space Environment: Applying NEPA to Federal and Federally Authorized Outer Space Activities," *Univ. Calif. Davis*, vol. 44, 2020.
[49] O. US EPA, "Greenhouse Gas Equivalencies Calculator." Accessed: Aug. 21, 2023. [Online]. Available: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator
[50] A. Rao, M. G. Burgess, and D. Kaffine, "Orbital-use fees could more than quadruple the value of the space industry," *Proc. Natl. Acad. Sci.*, vol. 117, no. 23, pp. 12756–12762, Jun. 2020, doi: 10.1073/pnas.1921260117.
[51] A. Levinson and M. S. Taylor, "Unmasking the Pollution Haven Effect*," *Int. Econ. Rev.*, vol. 49, no. 1, pp. 223–254, 2008, doi: 10.1111/j.1468-2354.2008.00478.x.
[52] "Carbon Border Adjustment Mechanism." Accessed: Jun. 29, 2023. [Online]. Available: https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en
[53] M. Copley, "How a European law might get companies around the world to cut climate pollution," *NPR*, May 17, 2023. Accessed: Jun. 29, 2023. [Online]. Available: https://www.npr.org/2023/05/17/1171238285/how-a-european-law-might-get-companies-around-the-world-to-cut-climate-pollution
[54] L. Fontagné and K. Schubert, "The Economics of Border Carbon Adjustment: Rationale and Impacts of Compensating for Carbon at the Border," *Annu. Rev. Econ.*, vol. 15, no. 1, p. null, 2023, doi: 10.1146/annurev-economics-082322-034040.
[55] C. Fischer and A. K. Fox, "Comparing policies to combat emissions leakage: Border carbon adjustments versus rebates," *J. Environ. Econ. Manag.*, vol. 64, no. 2, pp. 199–216, Sep. 2012, doi: 10.1016/j.jeem.2012.01.005.
[56] K. Rennert *et al.*, "Comprehensive evidence implies a higher social cost of CO2," *Nature*, vol. 610, no. 7933, Art. no. 7933, Oct. 2022, doi: 10.1038/s41586-022-05224-9.
[57] "ISO 14040:2006(en), Environmental management — Life cycle assessment — Principles and framework." Accessed: Jun. 07, 2023. [Online]. Available: https://www.iso.org/obp/ui/#iso:std:iso:14040:ed-2:v1:en
[58] Environmental management — Life cycle assessment — Requirements and guidelines, "Environmental management — Life cycle assessment — Requirements and guidelines," ISO. Accessed: Jun. 07, 2023. [Online]. Available: https://www.iso.org/standard/38498.html
[59] M. Biscarini *et al.*, "Dynamical Link Budget in Satellite Communications at Ka-Band: Testing Radiometeorological Forecasts With Hayabusa2 Deep-Space Mission Support Data," *IEEE Trans. Wirel. Commun.*, vol. 21, no. 6, pp. 3935–3950, Jun. 2022, doi: 10.1109/TWC.2021.3125751.
[60] D. Giggenbach, M. T. Knopp, and C. Fuchs, "Link budget calculation in optical LEO satellite downlinks with on/off-keying and large signal divergence: A simplified methodology," *Int. J. Satell. Commun. Netw.*, vol. 41, no. 5, pp. 460–476, 2023, doi: 10.1002/sat.1478.
[61] J. M. Gongora-Torres, C. Vargas-Rosales, A. Aragón-Zavala, and R. Villalpando-Hernandez, "Link Budget Analysis for LEO Satellites Based on the Statistics of the Elevation Angle," *IEEE Access*, vol. 10, pp. 14518–14528, 2022, doi: 10.1109/ACCESS.2022.3147829.



[62] N. Saeed, H. Almorad, H. Dahrouj, T. Y. Al-Naffouri, J. S. Shamma, and M.-S. Alouini, "Point-to-Point Communication in Integrated Satellite-Aerial 6G Networks: State-of-the-Art and Future Challenges," *IEEE Open J. Commun. Soc.*, vol. 2, pp. 1505–1525, 2021, doi: 10.1109/OJCOMS.2021.3093110.
[63] O. Popescu, "Power Budgets for CubeSat Radios to Support Ground Communications and Inter-Satellite Links," *IEEE Access*, vol. 5, pp. 12618–12625, 2017, doi: 10.1109/ACCESS.2017.2721948.
[64] R. Muttiah, "Satellite constellation design for 5G wireless networks of mobile communications," *Int. J. Satell. Commun. Netw.*, vol. 41, no. 5, pp. 441–459, 2023, doi: 10.1002/sat.1477.
[65] J. W. Hall, M. Tran, A. J. Hickford, and R. J. Nicholls, *The Future of National Infrastructure: A System-of-Systems Approach*. Cambridge University Press, 2016.
[66] K. T. Li, C. A. Hofmann, H. Reder, and A. Knopp, "A Techno-Economic Assessment and Tradespace Exploration of Low Earth Orbit Mega-Constellations," *IEEE Commun. Mag.*, vol. 61, no. 2, pp. 24–30, Feb. 2023, doi: 10.1109/MCOM.001.2200312.
[67] "Cost of Capital." Accessed: Jun. 30, 2023. [Online]. Available: https://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/wacc.html



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