

# **Frontiers in Public Health**

<https://www.frontiersin.org/journals/public-health/sections/occupational-health-and-safety>

## **Service sector and precarious working life: A crude look at a pragmatic epidemiology of hotel housekeeping**

By

Yorghos Apostolopoulos, PhD<sup>1</sup>

Sevil Sönmez, PhD<sup>2,\*</sup>

Yu-Chin (Jerrie) Hsieh, PhD<sup>3</sup>

Matthew S. Thiese, PhD<sup>4</sup>

Lazaros K. Gallos, PhD<sup>6</sup>

1. PROLEPSIS: Partners in Prevention, Inc., Orlando, Florida
2. College of Business, University of Central Florida, Orlando, Florida
3. Saunders College of Business, Rochester Institute of Technology, Rochester, New York
4. Rocky Mountain Center for Occupational and Environmental Health, University of Utah, Salt Lake City, Utah
5. Department of Computer Science, Rutgers University, Piscataway, New Jersey
6. DIMACS, Center for Discrete Mathematics & Theoretical Computer Science, Rutgers University, Piscataway, New Jersey

\* Corresponding author

## **ABSTRACT**

The COVID-19 pandemic has refocused attention on work as a key determinant of population health. Like other low-pay service-sector employees, hotel housekeepers—who were among the populations most affected by the pandemic—have a precarious working life with disproportionate health and other ramifications. These consequences are largely determined by, embedded in, and/or operate as complex, dynamic, and randomly determined systems with interacting components. Yet, prevailing epidemiology has not adequately delineated the complex and evolving etiology of multifaceted and far-reaching health risks of hotel housekeepers. This paper draws on accruing evidence indicating that the health challenges of working people can be more efficiently understood as comprehensive wholes with interacting components, and that it is the combination of interacting mixtures of exposures acting together that can induce health-related phenotype changes. Grounded in these assumptions and our evolving programmatic research, we introduce an emerging epidemiological discourse for hotel housekeeping based on integrative exposome and network epistemologies. This new look at a pragmatic epidemiology of hotel housekeeping is anchored in the working life exposome and network perspectives and, despite varied methodological challenges, has the potential to substantively enhance both science and prevention for disadvantaged service-sector workers and other working populations.

**Keywords:** Precarious working life, service-sector workers, hotel housekeepers, epidemiology of hotel housekeeping, working life exposome, multilayered networks

**Abstract wordcount:** 196

**Text wordcount:** 2,993

**Figures:** 2

**References:** 58

## **SERVICE SECTOR AND PRECARIOUS WORKING LIFE: A CRUDE LOOK AT A PRAGMATIC EPIDEMIOLOGY OF HOTEL HOUSEKEEPING**

### **INTRODUCTION**

The COVID-19 pandemic shed new light on the role of work in people's health, especially for disadvantaged socioeconomic strata that are regularly employed in precarious occupations (1, 2). Precarious work is consistently associated with both poor health and health disparities (3). Like other disadvantaged service-sector workers (e.g., low-pay retail workers) (4), hotel housekeepers (HHKs), who were particularly affected by the pandemic, experience a precarious working life with disproportionate health ramifications (5).

A multitude of interrelating work and nonwork exposures shape HHKs' overall health and wellbeing. Yet, prevailing hotel housekeeping (HHK) epidemiology has underestimated the totality, complexity, and dynamic interactions of these exposures with far-reaching implications (6). Grounded in our evolving *working life exposome* research (7, 8) and exposome (9) and network (10) epistemologies, we introduce a discourse for a pragmatic epidemiology of HHK to more fully delve into HHKs' precarious working life and their intractable health challenges.

### **HOTEL HOUSEKEEPERS' PRECARIOUS WORKING LIFE AND WELLBEING**

A central objective of globalization has been the reduction of both production and labor costs. Fewer legal and social protections for working and unemployed people, reduced bargaining power of labor, increases in temporary jobs, and weaker government regulations and oversight, together with growing immigration, have created a perfect storm of heightened risks for people of working age (11). Aside from significant increases in precarious work globally (12), COVID-19 underscored increasing work precarity, particularly among women and people of color (13).

Precarious work includes agency work, temporary "just-in-time" contracts, "on-call" and seasonal work, work at home and self-employment requiring workers to do the work in their free time, part-time irregular shiftwork, and work in the recently emerged "gig" sector (14). Key characteristics include unstable employment, harsh working conditions, few opportunities and benefits, low pay, unpredictable schedules, deficient worker rights and protections, and low levels of workers' control over wages and processes (11). These work arrangements are associated with overall poorer health outcomes (3), and even increased risk of premature death (15).

Low-pay service-sector workers—such as those working in retail, foodservice, and hotels—work largely in precarious work environments (16). HHKs, who clean hotel guestrooms, are mostly women, minorities, and immigrants, many of whom have limited education or struggle with English proficiency. They typically work eight-hour shifts five days a week, cleaning 12-16 guestrooms per shift. Unpredictable work schedules, hazardous work conditions, various adverse workplace exposures, low pay, limited fringe benefits, scarce opportunities for paid time-off, inadequate protections, and stressogenic psychosocial exposures collectively create conditions of high precarity for HHKs (17-22).

Immersed in these milieux for lengthy periods, HHKs face excess physical and psychological strains with wide-ranging ramifications (18). HHKs are exposed to elevated risks of repetitive-motion injuries, exhibiting the highest rates of musculoskeletal diseases (MSDs) among hotel employees (23). They are also exposed to biological and chemical hazards, leading to dermatological and respiratory problems (17). Because they work under time constraints, they regularly suffer from high levels of stress and associated accidents and injuries (20, 21). Notably, the nonfatal illness and injury rate for HHKs (5.4%) exceeds the national average for all occupations (24). These conditions place HHKs at mental and physical health disadvantages, raising their risk for chronic migraines, mental health disorders, cardiovascular syndemics, and mortality (25-34).

Yet, the effects of precarious work extend beyond the workplace and spill over to a precarious working life. As a result of these protracted and interrelated exposures, HHKs'

working lives are marked by intense strains from balancing work and family concerns, household socioeconomic insecurity and deprivation, housing and transportation challenges, increased psychological distress, and diminished sleep quality—all representing carryover effects from hotel housekeeping, and further exacerbated by documentation concerns for immigrants (17).

## **TOWARD A PARADIGM SHIFT IN HOTEL HOUSEKEEPING EPIDEMIOLOGY**

### **Current science can only go so far**

Considering the size of HHKs (largest worker segment of hotel/lodging industry), multiplicity and interdependability of their diverse exposures, and their disproportionate health challenges, there exists a dearth of comprehensive and rigorous epidemiological research. Current science has grossly underestimated the complexity of a multitude of multilayered work and nonwork domains influencing HHKs' health and wellbeing throughout their working years and beyond (6). This underestimation has, in turn, shaped the entire empirical research process (17-34).

Theoretical foundations mainly employ atheoretical, linear, individual-level, hotel-based, reductionist, and static conceptualizations. These approaches have led to research designs and methodologies that are heavily individual-level, deterministic, and cross-sectional, with surveys being the primary data collection method. Accordingly, analytical frameworks delve into usual associations between predetermined single, common, hotel-based, and individual-centered exposures—treating other exposures as confounders or effect modifiers—and single, common health outcomes at a time.

A PubMed review (2014-2024) corroborates this stark absence of rigorous empirical research that provides a complete and realistic picture of HHKs' intractable health challenges (35). Given that HHKs are a "hard-to-reach" population making comprehensive primary data collection quite challenging, adherence to foregoing narrow assumptions has hampered the implementation of rigorous longitudinal epidemiological research. An epistemological shift toward more holistic approaches would clearly contribute to the collection of higher quality and more comprehensive data that could catalyze a better understanding of HHKs' intractable challenges.

### **The *indispensable whole* of work-health-wellbeing**

Diverse empirical evidence (7, 36, 37) supports that: (a) population health challenges can be more fully understood when examined as *wholes* with interacting components; (b) it is the collection of interacting exposures acting together that induce health-related phenotype changes; and (c) relationships and properties of these interactions are crucial for a better understanding of health outcomes. Hence, the health challenges of working people can clearly be described as multilayered networks with their comprehensive delineation requiring the inclusion of all potential risk factors and effect modifiers.

Grounded in this rationale, and because HHKs' health challenges are clearly embedded in, determined by, and/or operate as complex systems, we cannot successfully analyze them by predetermining a set of factors, relationships, or properties that are studied separately and then recombining those partial approaches in an attempt to form an understanding of the *whole* (7). Instead, it is necessary to look at the *whole* multilayered network of entangled entities, even if at first it means taking a crude look, and then allowing possible simplifications to emerge from this approach. Based on these assumptions, synergistic exposome and network sciences can provide the foundation for a more pragmatic epistemological framework to more fully delineate the *indispensable whole*—that is, HHKs' working life and its effects on their health and wellbeing (7).

Exposome epistemologies highlight the importance of lifetime nongenetic influences for people's health (38)—given that the genome explains only a small proportion of the phenome (39). Network epistemologies emphasize that connections (or edges) among exposures (or

nodes) determine the function of *wholes* (networks/systems, represented as graphs) (10). Synergies of these complementary epistemologies can enhance our understanding of the *indispensable whole* of HHKs' work-health-wellbeing. For interested readers, detailed accounts of these epistemologies and methodologies are readily available (9, 10).

### The *working life exposome*

To advance our understanding of this *indispensable whole*, we draw upon syndemic, lifecourse, and ecosocial theories (40-42), and grounded in exposome and network sciences, we expand our evolving research on the *working life exposome* (7, 8) to other working populations. As already mentioned, we conceptualize HHKs' health challenges as multilayered networks, and introduce the *working life exposome of hotel housekeeping* (WLE-HHK). We understand the WLE-HHK as the totality of heterogeneous, multifactorial and interdependent work-related and in-/directly related nonwork exposures and associated biological responses and endogenous processes that concurrently and/or sequentially affect HHKs' health and wellbeing from conception onwards, throughout and beyond their working years. *Figure 1* depicts a simplified portrayal of HHKs' health challenges centered on the WLE-HHK and network attributes. A comprehensive description of the WLE is readily available for interested readers (7, 8, 43).

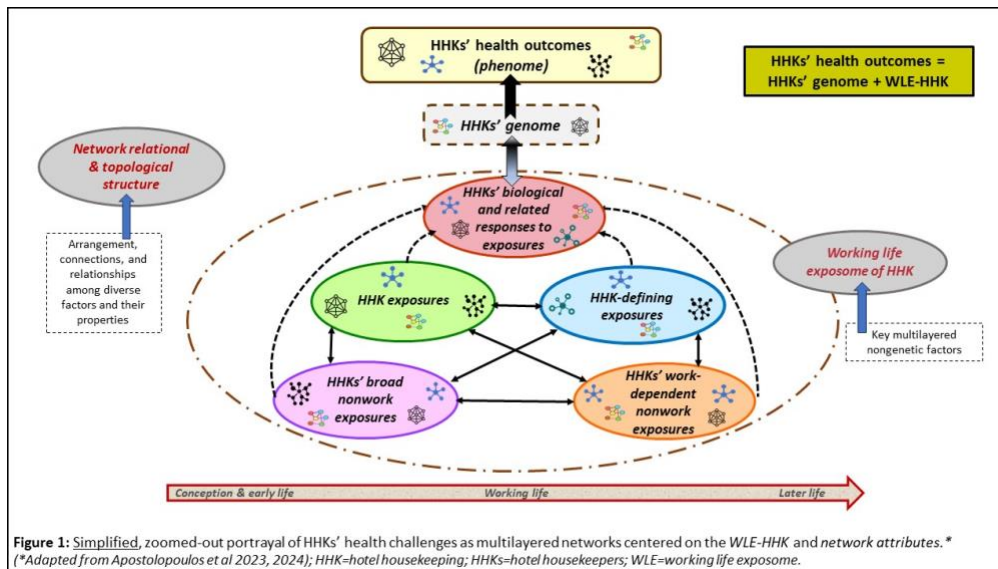


Figure 1: Simplified, zoomed-out portrayal of HHKs' health challenges as multilayered networks centered on the WLE-HHK and network attributes.\*  
 (\*Adapted from Apostolopoulos et al 2023, 2024); HHK=hotel housekeeping; HHKs=hotel housekeepers; WLE=working life exposome.

Key WLE-HHK components (17-34) include: (a) *HHK exposures* falling under the nature, conditions, and organization of HHK work; (b) *HHK-defining exposures* including government, labor, and related policies;

HHK-based policies, benefits, and rights; labor union rights and protections; and labor market characteristics; (c) *HHKs' broad nonwork exposures* involving socioeconomic, educational, labor, housing, health, environmental, and other forces, policies, and practices that influence all exposures; (d) *HHKs' work-dependent nonwork exposures* shaped by the foregoing, interacting exposures and including socioeconomic resources, residential neighborhood and housing conditions, as well as physical and chemical exposures outside work; and (e) *HHKs' biological and related responses to exposures* functioning as cumulative endogenous embodiment of exposures, including inflammatory, oxidative, and chronobiological processes as well as epigenetics, which can induce biological mechanisms. Mixtures of these interrelating exposures shape HHKs' health-related behaviors and unfold in work and nonwork milieus.

These multilayered WLE-HHK components interact among themselves in complex and evolving ways, as well as with HHKs' genome. It is the relational and topological arrangement, connections, and relationships among multilayered WLE-HHK components (44), HHKs' genome, and their emergent properties (i.e., various centralities) (44) that produce HHKs' dynamic health outcomes (phenome). These relationships can be best exemplified by the

simplified equation “*HHKs’ genome + WLE-HHK = HHKs’ health outcomes*,” as per exposomic conventions (45). Yet, while genetics are central, they are not as well understood for all types of health-related transitions and processes (e.g., cardiometabolic diseases vs. MSDs) (46). Of course, this evolving WLE-HHK conceptualization assumes that HHK as an occupation lasts for a minimum of several years.

The foregoing discussion indicates that this evolving paradigmatic shift toward a more comprehensive HHK epidemiology will clearly benefit from integrative exposome and network epistemologies and methodologies.

## **DISCUSSION**

### **Toward a pragmatic hotel housekeeping epidemiology**

This evolving paradigm shift both epitomizes HHKs’ actual health challenges and substantiates how integration of exposome and network theories, epistemologies, and methods can more efficiently explain the dynamic complexity of issues at hand. Below we elaborate on some of these enhancements in key research phases.

At the theoretical and conceptual level, these integrative frameworks can enable understanding of HHKs’ health challenges as complex and dynamic, comprehensive *wholes* with interacting multifactorial components. This conceptualization will define types of data collected and hypotheses tested, and can contribute toward the development of a theory framing HHKs’ wellbeing.

At the methodological level, these integrative frameworks can allow the: (a) systematic implementation of comprehensive longitudinal designs underpinned by the ubiquitous complexity of HHKs’ health challenges over their lifecourse, and (b) employment of data collection methods beyond surveys, grounded in exposure biomarker technologies, geographical mapping and remote sensing technologies, personal exposure sensors, and high-throughput molecular omics, among others (7).

Finally, at the analytical level, and especially due to ongoing and extensive knowledge gaps, integrative frameworks can facilitate both discovery- and hypothesis-driven approaches. Because traditional statistical approaches are not designed to delineate compound effects of multilayered components, combinations of novel analytical methods—taking advantage of stochastic analytical breakthroughs grounded in mathematical, statistical, and computational innovations—can advance understanding of HHKs’ health challenges over their lifecourse. These approaches can facilitate the delineation of relational patterns and topological properties as well as the identification of those critical sociostructural exposures that trigger biological perturbations leading to undesirable health outcomes—with an emphasis on their sources, early markers, routes, combinations, and critical phases prior to, during, and beyond HHKs’ working lifetime.

This integrative exposome-/network-based framework can catalyze meaningful enhancements in epidemiological research by accentuating the multiplicity, temporality, and variability of the *indispensable whole* of HHKs’ health challenges. This evolving framework can also afford us, for the first time, a crude glimpse at the pragmatic epidemiology of HHK.

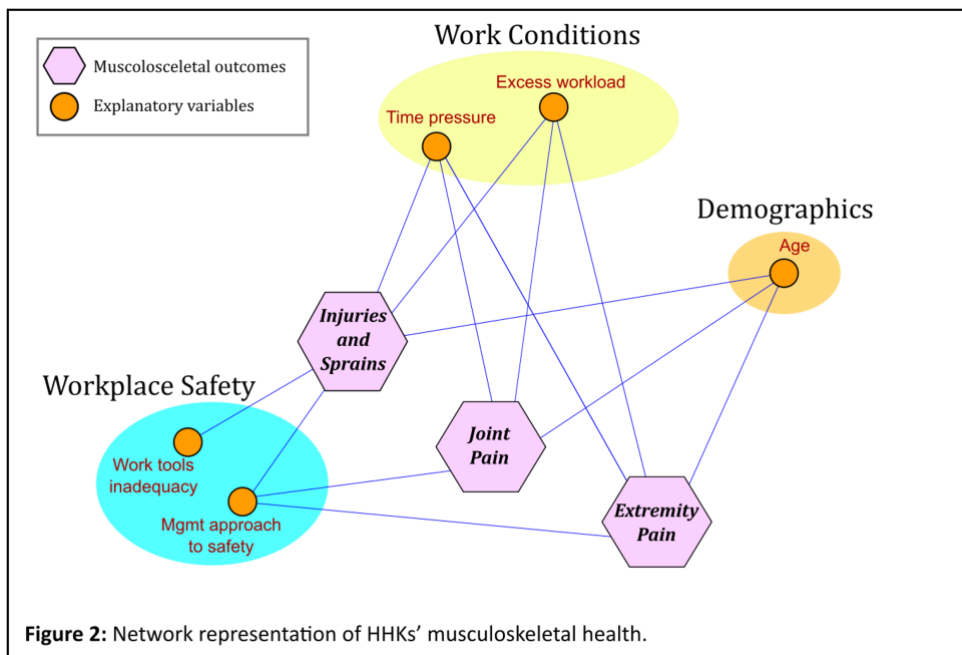
### **Harnessing the new paradigm**

Below we demonstrate how this new evolving paradigm can enhance understanding of HHKs’ persistent health challenges. We present a proof-of-concept grounded in network analysis—among various methods that can accentuate the strengths of this holistic framework. Given foregoing assumptions, insights and discussion, network analysis will allow us to more fully describe, explore, and delineate HHKs’ health challenges (10, 44).

Understanding how relationships among nodes can influence the behavior of the *whole* is crucial. Since HHKs’ exposures and outcomes are largely interdependent in complicated

patterns, we can miss crucial interplays unless we evaluate them as networks. We can examine patterns of relationships among variables (e.g., contribution of groups of nodes to single and/or multiple outcomes), and how different exposures and outcomes might be related to each other, by either correlational or causal relationships that will lead to large-scale networks. Network analysis allows the exploration of a larger space of exposures and outcomes, where single connections will now be substituted by factors that are densely connected in the network representation, thus providing deeper insights into unraveling HHKs' complex risk etiology.

Figure 2 demonstrates a simple network representation of HHKs' musculoskeletal health, based on a small dataset (N=140) (47). Because of data limitations, we follow a simple analytical path, examining only binary relations between nodes, which nevertheless can reveal the strengths of this paradigmatic direction. We use only a few explanatory variables (circles) representing HHKs' demographic, work conditions, and workplace safety factors. These independent variables are connected among themselves and to three musculoskeletal health outcomes (hexagons). Our main hypothesis is that these outcomes (injuries and sprains, joint pain, and extremity pain) are impacted by the entire system, as expressed by the interdependence of factors leading to this network depiction. For each outcome, we compare HHKs' sample related to this outcome ("outcome sample") with the sample of all other HHKs ("reference sample"). This comparison takes place for each explanatory variable, and we determine whether the two variable distributions in these groups are statistically different from each other. If distributions are different, then we connect the variable to the outcome with a line. This methodological approach can distinguish between a positive or negative impact on the outcome, but in this dataset, all explanatory variables have a positive effect. The distance between distributions is determined via a standard Kolmogorov-Smirnov test (48), except for binary distributions that are tested using a  $\chi^2$  test.



This representation shows that even with this imperfect dataset (i.e., small sample size, few explanatory variables, modest quality of variable groupings), we get meaningful information out of this network. For example, injuries and sprains (purple) are linked to the inadequacy of tools used for work, management's approach to safety

(teal cluster), HHKs' time pressures while working, excess workload (yellow cluster), and HHKs' age (orange). This representation illustrates that these nodes do not act independently but together with other nodes form an intricate web of interdependencies that need to be taken into account when planning interventions. For example, in case of elevated HHK injuries and sprains, combined corporate and labor union actions should consider concurrent improvements in all four



aforementioned areas, while possibly differentiating work assignments for older HHKs (given pronounced associations between ageing, musculoskeletal health, and work (49)). Yet, because we observe similar relational patterns for all musculoskeletal outcomes that can be explained by the imperfect data included in this proof-of-concept, we presume that a comprehensive WLE-HHK-informed dataset and a subsequent large-scale multilayered network will more fully and realistically uncover groups of factors that in/directly have the highest impact on HHKs' musculoskeletal health.

Finally, aside from network analysis methods, other combined analytical approaches are also commensurate with this emerging paradigm and appropriate for explicating complex WLE-HHK pathways. Indicative approaches (50) include: (a) exposome-wide association studies that have a discovery-driven focus; (b) methods that search for combined effects of exposures and/or their interactions (e.g., Bayesian methods); (c) methods that use artificial intelligence to maximize prediction performance (e.g., random forest); (d) multistage modeling methods for combined effects (e.g., exposure continuum mapping); (e) studies employing omics data to improve inference on connections between exposome-based predictors and health outcomes (e.g., multiomics mediation analysis); and (f) methods that search for causal relationships between environmental exposures and outcomes (e.g., causal random forests).

### **Challenges and implications of the new paradigm**

Despite its potential scientific contribution, this emerging paradigm can face challenges (51-53) typical of observational and exposomic designs that relate to: (a) collection and analysis of complex and large datasets over long periods; (b) measurement of multiple, heterogeneous exposures over the lifecourse; (c) assessment of causality due to multiple uncertainties; and (d) logistical constraints due to repeated collection of diverse biomarkers. However, evolving scientific and technological developments can provide innovative solutions to largely offsetting several of these perplexing challenges (54-57).

Finally, notwithstanding these challenges, this emerging integrative paradigm can serve as the foundation for a pragmatic HHK epidemiology with promising real-life benefits for HHKs. It can lead to a more comprehensive and accurate unravelling of the etiology of HHKs' complex health challenges that, in turn, can catalyze more efficacious preventive actions. For example, inclusion in our epidemiological models of evidence-based sociostructural domains—such as ordinances for a living wage and stable work schedules; employer-provided affordable family health insurance; union-related factors; enforcement of workshift breaks; provision and enforcement of worker protections; increased workplace safety; and paid time-off—among other macro-/meso-level factors, can largely contribute toward the identification of a more pragmatic underlying etiology of HHKs' persistent health challenges, with the potential for more efficacious interventions, policies, and other actions.

### **LOOKING INTO THE FUTURE**

We have recently been witnessing an increasing entrenchment of precarious work arrangements leading growing numbers of people into precarious working lives with pervasive implications for themselves, their families, and their communities—not to mention the national healthcare system. This is particularly true for several segments of service-sector workers, including HHKs. Given stark labor force shortages in various segments of the service sector (58), structural policy-based improvements, which can alleviate and even prevent some of the effects of precarious working lives, present themselves as promising avenues for governments, hotel/lodging corporations, and communities.

Emerging holistic epistemologies, garnered insights from exposome and network sciences, can enhance HHK epidemiology. Expansion of this evolving discourse can gradually lead to the emergence of a pragmatic HHK epidemiology that adheres to scientific breakthroughs and generates results that are more accurate. This epidemiological discourse can enrich



government and corporate actions that can synergistically improve the long-term health and wellbeing of disadvantaged HHKs, their families, and their communities. Finally, this discourse can have applications in the examination of intractable health challenges of other precarious working populations as well.

## REFERENCES

1. Eisen EA, Elser H, Picciotto S. Working: the role of occupational epidemiology. *Am J Epidemiol.*, volume 191, issue 2, February 2022, pp 237-240, <https://doi.org/10.1093/aje/kwab243>.
2. McNamara CL, McKee M, Stuckler D. Precarious employment and health in the context of COVID-19: a rapid scoping umbrella review. *Eur J Public Health.* 2021 Nov 9;31(Supplement\_4):iv40-iv49. doi: 10.1093/eurpub/ckab159. PMID: 34751369; PMCID: PMC8576296.
3. Pulford A, Thapa A, Thomson RM, Guiding A, Green MJ, Leyland A, Popham F, Katikireddi SV. Does persistent precarious employment affect health outcomes among working age adults? A systematic review and meta-analysis. *J Epidemiol Community Health.* 2022 Sep 22;76(11):909–17. doi: 10.1136/jech-2022-219292. Epub ahead of print. PMID: 36137738; PMCID: PMC9554022.
4. CDC/NIOSH Science Blog. Precarious work, job stress, and health-related quality of life. <https://blogs.cdc.gov/niosh-science-blog/2022/08/09/precarious-work/>. Accessed 4/15/24.
5. Chela-Alvarez X, Leiva A, Gallardo-Alfaro L, Bulilete O, Vidal-Thomas M, Llobera J. Anxiety, depression, and concern about employment status of hotel housekeepers in the Balearic islands during the COVID-19 pandemic: a longitudinal study. *Front Psychol.* 2022 Apr 5;13:842335. doi: 10.3389/fpsyg.2022.842335. PMID: 35478734; PMCID: PMC9037287.
6. Sönmez S, Apostolopoulos A, Lemke MK, Hsieh YC, Karwowski W. Complexity of occupational health in the hospitality industry: dynamic simulation modeling to advance immigrant worker health. *Int J Hosp Manag.*, v 67, 2017, pp 95-105, ISSN 0278-4319, <https://doi.org/10.1016/j.ijhm.2017.08.006>.
7. Apostolopoulos Y, Sönmez S, Thiese MS, Gallos LK. The indispensable *whole* of work and population health: how the working life exposome can advance empirical research, policy, and action. *Scand J Work Environ Health.* 2023 Mar 1;50(2):83-95.
8. Apostolopoulos Y, Sönmez S, Thiese MS, Olufemi M, Gallos LK. A blueprint for a new commercial driving epidemiology: An emerging paradigm grounded in integrative exposome and network epistemologies. *Am J Ind Med.* 2024 Jun;67(6):515-531. doi: 10.1002/ajim.23588. Epub 2024 Apr 30. PMID: 38689533.
9. Miller, GW, *The Exposome: A new paradigm for the environment and health.* Elsevier, 2020.
10. Barabasi, AL, Posfai, M. *Network Science.* Cambridge University Press, 2016.
11. Kalleberg AL. *Precarious lives: job insecurity and well-being in rich democracies.* Medford, MA: Polity Press, 2018.
12. Hickson J. Precarious work is on the rise: Why is this a problem? Blog. <https://www.liverpool.ac.uk/heseltine-institute/blog/precarious-work-is-on-the-rise/>. Accessed 2-20-2024.
13. Oddo VM, Jones-Smith J, Knox MA. Changes in precarious employment and health in the United States amidst the COVID-19 pandemic. *Prev Med Rep.*, 2023, <https://doi.org/10.1016/j.pmedr.2023.102113>.
14. International Labor Organization. Precarious work. [https://www.ilo.org/wcmsp5/groups/public/@ed\\_dialogue/@actrav/documents/meetingdocument/wcms\\_161381.pdf](https://www.ilo.org/wcmsp5/groups/public/@ed_dialogue/@actrav/documents/meetingdocument/wcms_161381.pdf). Accessed 3-3-2024.
15. Matilla-Santander N, Matthews AA, Gunn V, *et al* Causal effect of shifting from precarious to standard employment on all-cause mortality in Sweden: an emulation of a target trial. *J Epidemiol Community Health* 2023;77:736-743.

16. Choper, J., Schneider, D., Harknett, K. (2022). Uncertain Time: Precarious Schedules and Job Turnover in the US Service Sector. *ILR Review*, 75(5), 1099-1132. <https://doi.org/10.1177/00197939211048484>
17. Hsieh Y, Apostolopoulos Y, Sönmez, S. World at work: hotel cleaners. *Occup Environ Med.*, 2013, 70(5), 360–364.
18. Buchanan S, Vossen P, Krause N, Moriarty J, Frumin E, Shimek JA, . . . Punnett L. Occupational injury disparities in the US hotel industry. *Am J Ind Med*, 2010, 53(2), 116-125.
19. Sánchez-Rodríguez C, Capitán-Moyano L, Malih N, Yáñez AM, Bennasar-Veny M, Velasco-Roldán O, Bulilete O, Llobera-Canaves J. Prevalence of musculoskeletal disorders among hotel housekeepers and cleaners: a systematic review with meta-analysis. *Musculoskelet Sci Pract.*, 2024, 69, 102890. <https://doi.org/10.1016/j.msksp.2023.102890>.
20. Chela-Alvarez X, Bulilete O, Garcia-Illan E, Vidal-Thomàs M, Llobera J, Arenal Group. Hotel housekeepers and occupational health: experiences and perceived risks. *Ann Occup Environ Med.*, 2022, 34, e29. <https://doi.org/10.35371/aoem.2022.34.e29>.
21. Rosemberg MS, Li Y, McConnell DS, McCullagh MC, Seng JS. Stressors, allostatic load, and health outcomes among women hotel housekeepers: a pilot study. *J Occup Environ Hyg.*, 2019, 16(3), 206–217.
22. Unite Here (2020). Housekeeping can be dangerous work. <https://unitehere.org/wp-content/uploads/HousekeepingDangerous.pdf>. Accessed 1-30-24.
23. Sánchez-Rodríguez C, Capitán-Moyano L, Malih N, Yáñez AM, Bennasar-Veny M, Velasco-Roldán O, Bulilete O, Llobera-Canaves J. Prevalence of musculoskeletal disorders among hotel housekeepers and cleaners: A systematic review with meta-analysis. *Musculoskelet Sci Pract.* 2024 Feb;69:102890. doi: 10.1016/j.msksp.2023.102890. Epub 2023 Nov 30. PMID: 38081106.
24. Krause N. Work-related injury and illness among hotel housekeepers. <https://www.dir.ca.gov/dosh/doshreg/DrNKrauseppt.pdf>. Accessed 2/3/24.
25. Chela-Alvarez X, Garcia-Buades ME, Ferrer-Perez VA, Bulilete O, Llobera J. Work-family conflict among hotel housekeepers in the Balearic Islands (Spain). *PLOS One*, 2023, 18(3), e0269074. <https://doi.org/10.1371/journal.pone.0269074>.
26. Chela-Alvarez X, Bulilete O, García-Buades ME, Ferrer-Perez VA, Llobera J. Workplace bullying and sexual harassment at work among hotel housekeepers in the Balearic Islands (Spain). *Front Psychol.*, 2024, 14, 1241255. <https://doi.org/10.3389/fpsyg.2023.1241255>
27. Dinh-Dang D, Khafagy A, Krause N, Harris-Adamson C. Assessment of cardiovascular load among hotel room cleaners. *Appl Ergon.*, 2023, 106, 103886. <https://doi.org/10.1016/j.apergo.2022.103886>.
28. López-González AA, Manzanero Z, González San Miguel HM, Arroyo Bote S, Riutord Sbert P, Rigo Vives MDM, Ramírez Manent JI. Differences in cardiovascular risk levels between cleaning staff and hotel housekeepers. *J. Occup. Health*, 2022, 64(1), e12320. <https://doi.org/10.1002/1348-9585.12320>
29. Feaster MM. Work stress and blood pressure among hotel room cleaners: modeling impact and information bias. University of California Los Angeles, 2019.
30. Krause N, Arias OE. Disparities in prevalence, treatment, and control of hypertension among low wage immigrant workers beyond health insurance coverage: the Las Vegas hotel room cleaners' blood pressure study. *J Hypertens Manag.* 2015, 1:003. 10.23937/2474-3690/1510003.
31. Rosemberg MS, Ghosh B, Shaver J. Blood pressure and job domains among housekeepers. *J Health Dispar Res Pract.*, 2018, 11 (2), 100-115.
32. Rosemberg MS, Li Y, Polick C. Immigration-related stressors and health outcomes among low-wage immigrant hotel workers: a pilot study. *Public Health Nurs.*, 2022, 39(5), 1123–1127.

33. Sanon M. Hotel housekeeping work influences on hypertension management. *Am J Ind Med.*, 2013, 56 (12),1402-1413.
34. Powell PH, Watson D. Service unseen: the hotel room attendant at work. *Int J Hosp Manag.*, 2006, 25(2), 297–312.
35. PubMed search for 2014-2024 using terms “hotel” and “housekeepers.”  
[https://pubmed.ncbi.nlm.nih.gov/?term=hotel+and+housekeepers&filter=datesearch.y\\_10&ort=date](https://pubmed.ncbi.nlm.nih.gov/?term=hotel+and+housekeepers&filter=datesearch.y_10&ort=date). Accessed 5/22/24.
36. Patel CJ. Analytic complexity and challenges in identifying mixtures of exposures associated with phenotypes in the exposome era. *Curr Epidemiol Rep.*, 2017;4(1):22-30. doi: 10.1007/s40471-017-0100-5. Epub 2017 Jan 18. PMID: 28251040; PMCID: PMC5306298.
37. Henry TR, Duffy KA, Rudolph MD, Nebel MB, Mostofsky SH, Cohen JR. Bridging global and local topology in whole-brain networks using the network statistic jackknife. *Netw Neurosci.*, 2020 Feb 1;4(1):70-88. doi: 10.1162/netn\_a\_00109. PMID: 32043044; PMCID: PMC7006875.
38. Wild CP. Complementing the genome with an "exposome": the outstanding challenge of environmental exposure measurement in molecular epidemiology. *Cancer Epidemiol Biomarkers Prev.* 2005 Aug;14(8):1847-50. doi: 10.1158/1055-9965.EPI-05-0456. PMID: 16103423.
39. Rappaport SM. Genetic factors are not the major causes of chronic diseases. *PLoS One* 2016. Apr;11(4):e0154387. 10.1371/journal.pone.0154387.
40. Mendenhall E. Syndemics: a new path for global health research. *Lancet.* 2017 Mar 4;389(10072):889-891. doi: 10.1016/S0140-6736(17)30602-5. PMID: 28271827.
41. Jones NL, Gilman SE, Cheng TL, Drury SS, Hill CV, Geronimus AT. Life course approaches to the causes of health disparities. *Am J Public Health*, 2019 Jan;109(S1):S48-S55. doi: 10.2105/AJPH.2018.304738. PMID: 30699022; PMCID: PMC6356123.
42. Krieger N. *Epidemiology and the people’s health: theory and context.* Oxford University Press. 2011. ISBN 9780199750351.
  
43. Pronk A, Loh M, Kuijpers E, Albin M, Selander J, Godderis L, Ghosh M, Vermeulen R, Peters S, Mehlum IS, Turner MC, Schlünssen V, Goldberg M, Kogevinas M, Harding BN, Solovieva S, Garani-Papadatos T, van Tongeren M; EPHOR Consortium; Stierum R. Applying the exposome concept to working life health: the EU EPHOR project. *Environ Epidemiol.*, 2022 Feb 17;6(2):e185. doi: 10.1097/EE9.000000000000185.
44. Newman M. *Networks.* Oxford University Press, 2018.
45. Kelly C. Data science may resolve how environment influences disease. Accessed from <https://factor.niehs.nih.gov/2021/1/science-highlights/data-science>, 2/13/24.
46. Tsepilov YA, Freidin MB, Shadrina AS. et al. Analysis of genetically independent phenotypes identifies shared genetic factors associated with chronic musculoskeletal pain conditions. *Commun Biol.*, 3, 329 (2020). <https://doi.org/10.1038/s42003-020-1051-9>.
47. Shapoval V, Sönmez S, Hsieh YJ, Apostolopoulos Y. Occupational health and safety of immigrant hotel housekeepers. *Workplace Health Saf.* 2022 Dec;70(12):566-573. doi: 10.1177/21650799221090712. Epub 2022 May 14. PMID: 35574928.
48. Berger VW, Zhou Y. Kolmogorov-Smirnov test: overview. *Wiley StatsRef: Statistics Reference Online* 2014. <https://doi.org/10.1002/9781118445112.stat06558>.
49. Palmer KT, Goodson N. Ageing, musculoskeletal health and work. *Best Pract Res Clin Rheumatol.* 2015 Jun;29(3):391-404. doi: 10.1016/j.berh.2015.03.004. Epub 2015 Apr 15. PMID: 26612237; PMCID: PMC4762198.
50. Maitre L, Guimbaud JB, Warembourg C, Güil-Oumrait N, Petrone PM, Chadeau-Hyam M, Vrijheid M, Basagaña X, Gonzalez JR; Exposome Data Challenge Participant Consortium. State-of-the-art methods for exposure-health studies: Results from the exposome data

- challenge event. *Environ Int.* 2022 Oct;168:107422. doi: 10.1016/j.envint.2022.107422. Epub 2022 Aug 27. PMID: 36058017.
51. Borsboom D, Deserno MK, Rhemtulla M. et al. Network analysis of multivariate data in psychological science. *Nat Rev Methods Primers*, 1, 58, 2021. <https://doi.org/10.1038/s43586-021-00055-w>.
  52. Zhang P, Arora M, Chaleckis R, Isobe T, Jain M, Meister I, Melén E, Perzanowski M, Torta F, Wenk MR, Wheelock CE. Tackling the complexity of the exposome: considerations from the Gunma University initiative for advanced research (GIAR) exposome symposium. *Metabolites*. 2019 Jun 6;9(6):106. doi: 10.3390/metabo9060106. PMID: 31174297; PMCID: PMC6631702.
  53. Hilton Boon M, Burns J, Craig P, Griebler U. et al. Value and challenges of using observational studies in systematic reviews of public health interventions. *Am J Public Health*. 2022 Apr;112(4):548-552. doi: 10.2105/AJPH.2021.306658. PMID: 35319925; PMCID: PMC8961824.
  54. Neal ZP, Forbes MK, Neal JW. et al. Critiques of network analysis of multivariate data in psychological science. *Nat Rev Methods Primers* 2, 90 (2022). <https://doi.org/10.1038/s43586-022-00177-9>.
  55. Zhang P, Carlsten C, Chaleckis R, Hanhineva K, Huang M, Isobe T, Koistinen VM. et al. Defining the scope of exposome studies and research needs from a multidisciplinary perspective. *Environ Sci Technol Lett*. 2021, 8 (10), 839-852 DOI:10.1021/acs.estlett.1c00648.
  56. Warembourg C, Anguita-Ruiz A, Siroux V. et al. Statistical approaches to study exposome-health associations in the context of repeated exposure data: a simulation study. *Environ. Sci. Technol*. 2023, 57 (43), 16232-16243. DOI: 10.1021/acs.est.3c04805.
  57. Shimonovich M, Pearce A, Thomson H. et al. Assessing causality in epidemiology: revisiting Bradford Hill to incorporate developments in causal thinking. *Eur J Epidemiol* 36, 873–887 (2021). <https://doi.org/10.1007/s10654-020-00703-7>.
  58. US Chamber of Commerce. America Works Data Center. <https://www.uschamber.com/workforce/america-works-data-center>. Accessed 5/2/24.