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**A work-inclusive, exposome-based epistemology to enhance data and inferences
in chronic disease epidemiology**

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Abstract

Despite pronounced associations between work and health, work-related data are consistently underrepresented in chronic disease epidemiological research. Prevailing epidemiological conceptualizations and empirical models rarely include pertinent work-related variables necessary to fully capture chronic disease challenges or states of working people, or they provide inadequate or inaccurate measures of important variables. These omissions and distortions can compromise data integrity, raise data bias concerns, lead to skewed findings, threaten validity, and ultimately lead to incomplete assessments of chronic disease risks. In this paper, we not only acknowledge the pivotal role of work in population health, but we also introduce a work-inclusive, exposome-based epistemological framework that comprehensively integrates the lifetime, nongenetic etiological “universe” of exposures that can enhance data quality and more accurately explain chronic disease burden and disparities. This emerging chronic disease exposome is the totality of an array of complex, heterogeneous, multifactorial, and interdependent—broad and specific—living and work environment exposures, endogenous processes, and associated biological responses that can concurrently and/or sequentially shape people’s chronic health challenges from conception onwards. The chronic disease exposome is grounded in synergies of population health, exposome, network, and complex systems theoretical and empirical perspectives, omic data collection technologies, machine learning and artificial intelligence, as well as big data. Given the growing support for more holistic and ultimately pragmatic approaches in chronic disease epidemiology, despite methodological and analytical challenges, this emerging work-inclusive, exposome-based framework is anticipated to enhance data quality, improve accuracy of chronic disease estimations, and ultimately inform more comprehensive policies and impactful actions.

Key messages

- **What is already known on this topic** – *While work plays a central role in population health, work-related data have been largely underrepresented in chronic disease epidemiology, potentially leading to skewed findings, explanations, and conclusions.*
- **What this study adds** – *The introduction of the emerging, work-informed chronic disease exposome, as a summary measure of multiple and interdependent work-related exposures over the lifecourse, which can potentially improve pertinent data and lead to a better understanding of causal mechanisms and outcomes in chronic disease epidemiology.*
- **How this study might affect research, practice, or policy** – *The systematic development of the emerging work-inclusive, exposome-based epistemological and methodological framework shifts the prevailing paradigm by catalyzing more holistic and pragmatic research approaches in chronic disease epidemiology, thereby leading to more accurate conclusions and eventually to more efficacious policies and diverse actions.*

Keywords

Epidemiological methodology; data integrity; chronic disease epidemiology; work/employment/occupation; work-related data; working life exposome; chronic disease exposome

A WORK-INCLUSIVE, EXPOSOME-BASED EPISTEMOLOGY TO ENHANCE DATA AND INFERENCE IN CHRONIC DISEASE EPIDEMIOLOGY

Introduction: The perils of imperfect data

Notwithstanding documented associations between work and health,¹ important *work-related* data remain underrepresented in chronic disease research. Despite the unparalleled contribution of surveillance systems and seminal epidemiological studies to disease prevention, the gamut of *work-related* factors that may contribute to a comprehensive understanding of disease mechanisms remains underexplored, possibly leading to inferences of dubious validity.

Prevailing epidemiological research has focused narrowly on specific workplace hazards. However, given the increasing prevalence of chronic disease, evolving organization of work, and the need for the accurate depiction of both in policies and actions, there is an urgent need to develop epistemologies that more accurately reflect the complex interactions between work and health. Herein, we initiate an evolving discourse on how a comprehensive, work-inclusive framework can improve data quality and ultimately the validity of inferences in chronic disease epidemiology.

We have organized the paper as follows: (1) we discuss the importance of the totality of interdependent *work-related* factors in delineating health challenges; (2) we substantiate how *work-related* data are underrepresented in chronic disease epidemiology; and (3) we introduce a work-inclusive, exposome-based framework that can enhance data and inferences in chronic disease epidemiology.

The indispensable *whole* of work and health

Working-age Americans devote substantial resources to *work-related* endeavors. Spanning across occupations, a multitude of *work-related* factors play an unequivocal role in shaping chronic disease outcomes over the lifecourse.¹ Together with other multifaceted domains, the work environment contributes to an increased risk for cardiometabolic diseases, cancer, sleep disturbances, and mental health conditions, among other comorbidities,¹ with repercussions beyond people's working years.

Numerous studies with objective quantification of *work-related* exposures have shown that work significantly affects health. For instance, long workhours influence cardiovascular burden,² shiftwork is linked to circadian rhythm disruptions and related cardiometabolic risks,³ and overall workplace exposures are attributed responsibility for 8.4% of cancer mortality.⁴ Had these markers included additional factors that are largely determined by work (e.g., paid sick leave) and that markedly affect health, the attributable *work-related* disease burden would clearly be higher.

Chronic disease epidemiology has underestimated the range of *work-related* influences on people's health. We have recently introduced a comprehensive account of the *working life exposome*⁵⁻⁷ as a summary measure of exposures that can potentially influence the health of working people. It includes co-occurring and interdependent *work-related* influences and their biological implications unfolding during people's working life and beyond. The nonbiological components of the *working life exposome* include: (1) *work-specific exposures* that unfold in, originate from, and are associated with work milieus, having immediate or delayed effects on people's wellbeing, e.g., working conditions; (2) *work-defining exposures* that are mainly policies originating outside immediate work milieus, defining *work-specific exposures*, affecting people's lives at and outside work, and having a sustained bearing on their wellbeing beyond work years, e.g., labor policies; and (3) *work-dependent (nonwork) exposures* that originate outside work milieus, interact with and are affected by *work-specific*, *work-defining*, and *broad nonwork exposures* (rooted in sociocultural structures and institutions, and influencing people's wellbeing, e.g., social and health policies), and synergistically shape people's wellbeing throughout their lives, e.g., residential neighborhood conditions.

The *working life exposome* encompasses the full spectrum of interdependent exposures that can potentially determine the disease burden of working-age people. Because health challenges of working people can be more fully understood as *wholes* with interacting parts,⁵⁻⁷ omission of relevant *work-related* measures can seriously distort the potential etiology of chronic disease risk, thereby possibly influencing the validity of our inferences.

Underrepresentation of *work-related* data

Epidemiological data should be as accurate, complete, valid, and reliable as possible, to contribute to a comprehensive understanding of health circumstances. When epidemiological investigations do not include necessary data to fully capture chronic disease challenges or when they provide inadequate or inaccurate measures, such omissions, misrepresentations, or distortions can compromise data integrity. Such instances can become concerns for data bias and threats for validity, and can ultimately lead to skewed inferences. Along these lines, work/occupation/employment data are regularly underrepresented in chronic disease epidemiology—as a proof-of-concept, below we scrutinize indicative health data systems and chronic disease-related datasets.

Work/occupation/employment data are underrepresented in national health data surveillance systems that can be used to delineate chronic disease burden. A 2018 National Academies report calls for an overhaul of the types and collection methods of *work-related* health surveillance data,⁸ while a 2024 CDC/NIOSH scientist-authored manuscript highlights this very poverty of *work-related* data.⁹ For the latter in particular, a team of CDC/NIOSH scientists evaluated 39 national health surveillance and monitoring systems and found that only 12 collected at least minimal *work-related* data (e.g., employment status). They concluded that this limited and inconsistent collection of robust *work-related* information could have, among others, repercussions for national health-disparity reduction efforts.

Building on and expanding the findings of CDC/NIOSH scientists,⁹ we selected four premier national health data systems—the *Behavioral Risk Factor Surveillance System (BRFSS)*,¹⁰ *National Health and Nutrition Examination Survey (NHANES)*,¹¹ *National Health Interview Survey (NHIS)*,¹² and *Quality of Worklife/General Social Survey (QWL/GSS)*¹³—that play a central role in social and health policy development. Because these data systems also include basic chronic disease-related outcomes, they were examined for the inclusion of *work-related* data and were then contrasted with more comprehensive *work-related* domains.⁵⁻⁷

On the one hand, the *BRFSS* and *NHANES* include overall similar, limited *work-related* questions that can be used to explain chronic health conditions. Minimal *work-specific* data include questions on employment status, reasons unemployed, current/longest held occupation, industry type, shiftwork, and workplace contaminants. Minimal *work-defining* and *work-dependent (nonwork)* data include questions on health insurance, safety climate, and household income. Overall, when compared with comprehensive *work-related* domains,⁵⁻⁷ *BRFSS* and *NHANES* provide inadequate data on work organization and working conditions, government and corporate labor and other policies influencing worker health, and work-dependent (nonwork) resources, among others, that are instrumental in population health.

On the other hand, the *NHIS* and *QWL/GSS* provide a different account of *work-related* data. As the foremost national health data collection system, the annual *NHIS* does not provide consistent, detailed *work-related* data, except for information on employment status and current job. Only in 2010, 2015, and 2021, when NIOSH incorporated *work-related* questions, did *NHIS*' Occupational Health Supplement include: (a) detailed *work-specific* data including questions on reasons/duration unemployed, change in employment status/hours, work activity/duties, location, hours, arrangement and schedule, current/usual/longest industry/occupation worked in/held, work exposure hazards, and workplace psychosocial conditions, and (b) minimal *work-defining* and *work-dependent (nonwork)* data including questions on workers' compensation, household income, pay, and benefits. When compared to comprehensive *work-*

related domains,⁵⁻⁷ *work-defining* (e.g., labor policies) and *work-dependent (nonwork)* (e.g., residential neighborhood) measures are very limited. Further, the QWL/GSS measures, among others, how work organization influences worker health, and includes questions on hours of work, workload, worker autonomy, layoffs and job security, job satisfaction/stress, as well as others. It does not collect regular biennial *work-related* data (like the GSS), and only the 2002, 2006, 2010, 2014, 2018, and 2022 versions include the complete *Quality of Working Life* variables. Overall, it contains detailed *work-specific* data (e.g., workshift, overtime, work arrangements) but overall limited *work-defining* and *work-dependent (nonwork)* data, including only questions on pay status, income, and health insurance, most of which come from GSS. *Table 1* presents a summary of our evaluation of BRFSS, NHANES, NHIS, and QWL/GSS, contrasted with comprehensive *work-related* domains.⁵⁻⁷

Table 1: *Work-related* variables included in BRFSS, NHANES, NHIS, and QWL/GSS, contrasted with comprehensive *work-related* domains.

COMPREHENSIVE WORK-RELATED DOMAINS ¹	INDICATIVE NATIONAL HEALTH DATA SYSTEMS INCLUDING CHRONIC DISEASE-RELATED OUTCOMES			
	BRFSS ²	NHANES ³	NHIS ⁴	QWL/GSS ⁵
WORK-SPECIFIC EXPOSURES				
Broad variable categories (sample)	Specific questions (specific variables or variable categories)			
Working conditions/exposures	Reasons unemployed	Reasons unemployed	Employment status	Employment status
Workload characteristics	Industry type	Workhours and total workhours	Reasons and duration unemployed	Current occupation and industry
Organizational work environment	Current occupation	Current and longest held occupation	Change in employment status and hours	Work location
Work-life balance	Work contaminants	Workshift	Employer name	# of jobs currently held
Health behaviors at work	Employment status	Employment status	Current/usual/longest industry	Duration/reasons unemployed
			Current/usual/longest held occupation	Work/nonwork balance
			Main work activity/duties	Work arrangements*
			Work location, hours, arrangement, schedule*	Total hours worked at all jobs*
			Work exposure hazards*	Workshift and overtime
			Workplace psychosocial conditions*	Workplace psychosocial conditions*
			Schedule control/flexibility*	Work schedule and hours*
				Ergonomic stressors*
WORK-DEFINING EXPOSURES				
Broad variable categories (sample)	Specific questions (specific variables or variable categories)			
Government industry-specific policies (e.g., transport policies)	Health insurance	Safety climate	Workers' compensation	Pay and benefits*
	Type of insurance	Health insurance	Health insurance	Safety climate*
Government industry-specific labor policies (e.g., hours-of-service rules for transport)		Type of insurance	Pay and benefits	Health insurance
Corporate policies and operations (e.g., fringe benefits)				
WORK-DEPENDENT (NONWORK) EXPOSURES				
Broad variable categories (sample)	Specific questions (specific variables or variable categories)			
Personal/family socioeconomic resources	Household income	Household income	Household income	Household income*
Personal/family neighborhood conditions/realities			Income stability*	

Personal/family health history				
Health behaviors at home				
¹ Based on our <i>working life exposome</i> research (see References 5-7); ² Behavioral Risk Factor Surveillance System; ³ National Health and Nutrition Examination Survey; National Health Interview Survey; ⁵ Quality of Worklife/General Social Survey; * Occasional collection.				

Work/occupation/employment data are underrepresented in major chronic disease epidemiological datasets as well. Seminal studies such as the *Coronary Artery Risk Development in Young Adults* study (CARDIA),¹⁴ *Multi-Ethnic Study of Atherosclerosis*,¹⁵ *Framingham Heart Study*,¹⁶ and *Hispanic Community Health Study/Study of Latinos (HCHS/SOL)*,¹⁷ among others, follow suit. Our examination of the most-influential CARDIA and HCHS/SOL datasets, once again, underscores this dearth of *work-related* data.

To start with, long-standing CARDIA delves into delineating coronary heart disease (CHD) development. We reviewed the “CARDIA exam components-All years-2022” and “CARDIA sociodemographic questionnaire-Year 35-2021” documents¹⁸⁻¹⁹ to ascertain questions that included work/occupation/employment. Besides inadequate *work-specific* questions—such as occupation, income, and job strain—CARDIA also includes limited *work-defining* questions—such as medical coverage—and few *work-dependent (nonwork)* questions—such as living situation, resources/debt, neighborhood socioeconomic deprivation, and unemployment. This conspicuous underrepresentation of *work-related* measures was also demonstrated by the publication of only 31 (out of 836) peer-reviewed publications that narrowly examined the role of work/occupation/employment in CHD (PubMed search for 1987-2024, conducted independently by two coauthors in June 2024).

Newer HCHS/SOL examines chronic disease risk of U.S. Hispanics/Latinos. In reviewing the “HCHS Derived Variable Dictionary-2020”²⁰ and “HCHS Occupational Questionnaire” documents,²¹ we assessed work/occupation/employment-related questions that were included in relevant protocols. Again, only a limited number of *work-specific* (e.g., income, work schedule, exposures to chemicals, metals and pesticides), *work-defining* (e.g., health insurance coverage), and *work-dependent (nonwork)* (e.g., healthy eating index, residential stability, neighborhood socioeconomic deprivation, unemployment) questions were included in data collection protocols. This striking underrepresentation of *work-related* measures was also obvious by the publication of only 21 (out of 312) peer-reviewed articles examining associations between narrowly defined work/occupation/employment measures and chronic health challenges (PubMed search for 2010-2024, conducted independently by two coauthors in June 2024).

Overall, both CARDIA and HCHS/SOL datasets: (a) provide inadequate *work-specific* measures; for instance, work design and/or organization or ergonomic exposures— independently associated with chronic disease outcomes in mainly occupational health studies²²—were absent; (b) include only limited *work-defining* measures; for example, corporate labor policies, employment-based policies and employee rights, or labor unionization—also independently associated with chronic disease outcomes originating mainly from occupational health studies²³—were also absent; and (c) do not include comprehensive measures on *work-dependent (nonwork) exposures*; for example, personal and/or family socioeconomic resources and personal and/or family health history—also independently associated with chronic disease outcomes originating mainly from population health studies²⁴—were absent as well. These significant data gaps may contribute to the underestimation of the role of work in chronic disease development, leading to insufficient policy responses. *Table 2* presents a summary of our evaluation of CARDIA and HCHS/SOL datasets, and is contrasted to comprehensive *work-related* domains.⁵⁻⁷

Table 2: *Work-related* variables included in CARDIA and HCHS/SOL datasets, contrasted with comprehensive *work-related* domains.

COMPREHENSIVE WORK-RELATED DOMAINS ¹	INDICATIVE CHRONIC-DISEASE FOCUSED EPIDEMIOLOGICAL DATASETS	
	CARDIA ²	HCHS/SOL ³
WORK-SPECIFIC EXPOSURES		
Broad variable categories (sample)	Specific questions (variables)	
Working conditions and exposures	Occupation	Occupation
Workload characteristics	Income	Income
Organizational work environment	Job strain	Work schedule
Work-life balance	Employment status	Employment status
Health-related behaviors at work		Exposures to solvents, metals, and pesticides
		Work-related physical activity
WORK-DEFINING EXPOSURES		
Broad variable categories (sample)	Specific questions (variables)	
Government industry-specific policies (e.g., maritime policies)		
Government industry-specific labor policies (e.g., hours-of-service rules)		
Corporate policies and operations (e.g., benefits and rights)	Medical coverage	Health insurance coverage
WORK-DEPENDENT (NONWORK) EXPOSURES		
Broad variable categories (sample)	Specific questions (variables)	
Personal and family socioeconomic resources	Living situation	Healthy eating index
Personal and family neighborhood conditions and realities	Resources and/or debt	Residential stability
Personal and family health history	Neighborhood socioeconomic deprivation	Neighborhood socioeconomic deprivation
Health-related behaviors away from work	Unemployment	Unemployment

¹ Based on our *working life exposome* research (see References 5-7); ² Reviewed documents include *CARDIA Exam Components-All Years-2023* and *CARDIA Sociodemographic Questionnaire-Year 35-2021* (see References 18, 19); ³ Reviewed documents include *HCHS Derived Variable Dictionary-2020* and *HCHS Occupational Questionnaire* (see References 20, 21).

In sum, this underrepresentation of *work-related* data in both national surveillance data systems and major epidemiological datasets that can be used in chronic disease research is only the tip of the iceberg with far-reaching ramifications. This underrepresentation becomes even more pronounced when compared to related epidemiological data collected in comparable countries. Indicative examples of European datasets, for example, include a wealth of comprehensive *work-related* data providing extensive coverage of pertinent *work-related* information—invaluable for more accurate inferences, policy development, and actions.²⁵

A work-inclusive, exposome-based framework can enhance data and inferences

In the context of overall inconsequential (workplace-based²⁶ and chronic-disease-focused²⁷) individual-level interventions, fast-evolving world of work, proliferation of complex systems and exposome sciences, calls for comprehensive frameworks in chronic disease epidemiology,²⁸ artificial intelligence advances, novel data-collection technologies,²⁹ and big-data explosion, the foregoing discussion clearly points toward the direction of more holistic approaches to examining health challenges of working people. Recent programmatic papers also highlight the importance of broader *work-related* influences in delineating chronic disease burden.³⁰

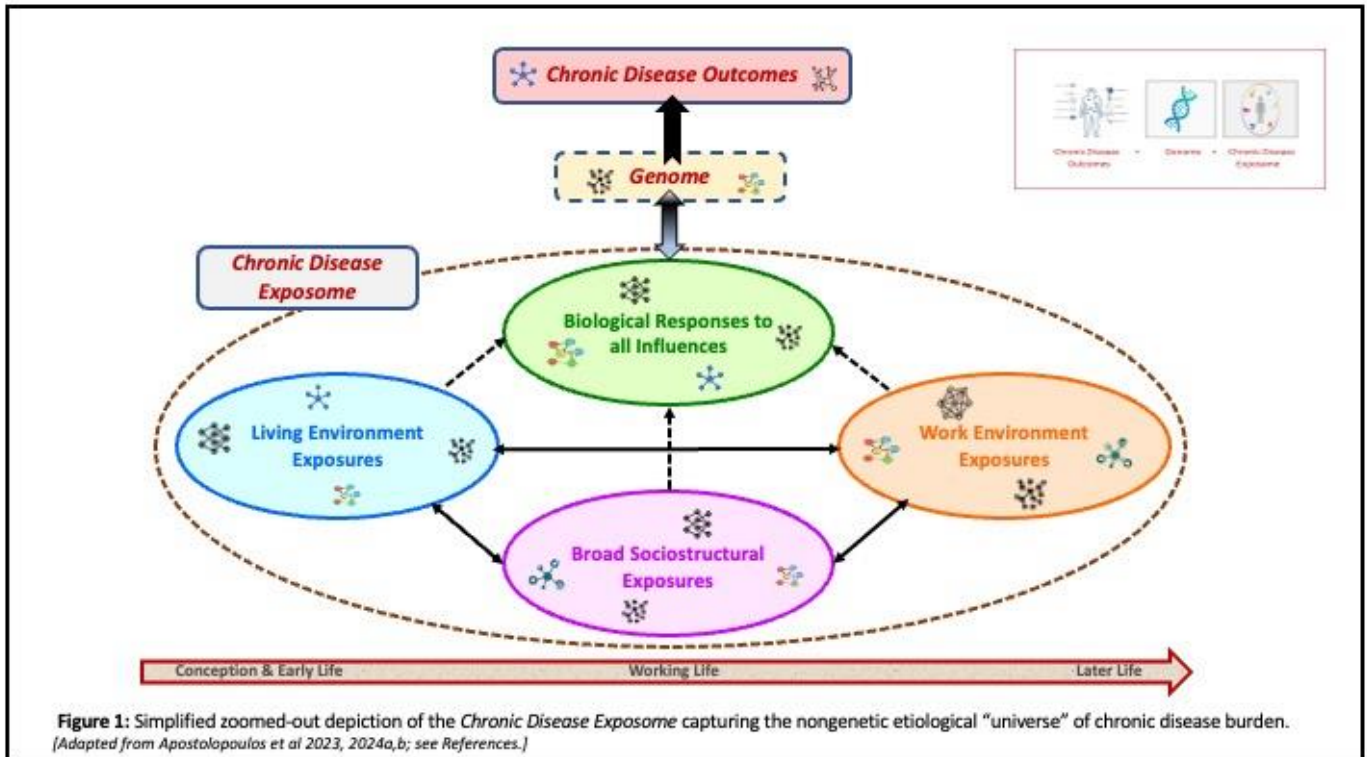
Building on foregoing evidence and our ongoing work,⁵⁻⁷ we contend that the *working life exposome* is a potentially efficacious epistemological framework when focusing on the health effects of specific occupations and/or work environments. However, we believe that, in this

case, the *working life exposome* can be transformed into a comprehensive *chronic disease exposome* that is more appropriate when delving specifically into disease challenges of working populations. Thus, expanding our evolving work, and grounded in synergies of population health theories⁵⁻⁷ and exposome³¹ and network³² sciences, we view the *chronic disease exposome as the totality of an array of heterogeneous, multilayered, multifactorial, and interdependent—broad and specific—living and work environment exposures, endogenous processes, and associated biological responses that can concurrently and/or sequentially impact people’s persisting health challenges from conception onwards.*

This evolving *chronic disease exposome* conceptualization places work firmly at the center of chronic disease epidemiology while highlighting the *indispensable whole* of interdependent lifetime *work-related* exposures that can shape chronic disease development. It represents an integrated function of internal, external, personal, organizational, and structural influences and their biological implications throughout people’s lives. It includes the lifetime, nongenetic etiological “universe” of possible exposures (i.e., confounding, effect modifier, mediating, and other variables) that can potentially explain chronic disease development. For example, the application of this framework to *CARDIA* data could reveal previously unrecognized relationships between occupational stress or shiftwork and cardiovascular outcomes.

The *chronic disease exposome* includes four broad, multilayered, and interacting components: (1) *broad sociostructural exposures* that are rooted in broader culture, institutions, and social structures, and directly or indirectly shape people’s wellbeing. They involve sociocultural, political, economic, labor, health, agricultural, environmental, and other forces, policies, and practices that influence all other exposures;⁵⁻⁷ (2) *work environment exposures* that fall under the framework, conditions, organization, exposures, and remuneration of work, and include broad working conditions; government labor and related policies (e.g., equal pay protections); work/employment-based policies, benefits, and rights (e.g., paid family leave); labor union rights/protections; labor market characteristics (e.g., occupational segregation); social demography; and health-related behaviors linked to work;⁵⁻⁷ (3) *living environment exposures* that are affected by interacting *broad sociostructural* and *work environment exposures*, including socioeconomic resources (e.g., social capital); neighborhood conditions (e.g., safe housing); physical and chemical exposures outside work; various health-related behaviors outside work; and sociodemographic properties (e.g., race/ethnicity),⁵⁻⁷ among others; and (4) *biological responses to all influences* and their interactions are endogenous processes that encompass inflammatory factors, oxidative challenges, chronobiological fluctuations, epigenetics, and other processes, which can induce disease mechanisms and outcomes.⁵⁻⁷ This framework was developed through a systematic analysis of existing epidemiological models, integration of exposome and network epistemologies, and iterative refinement based on expert feedback and observational data.

Figure 1 depicts a heuristic, simplified portrayal of a multilayered network of networks that highlights key functions of a work-inclusive exposome in chronic disease development and proliferation. Each multifactorial *chronic disease exposome* component includes multiple factors and networks that interact among themselves and factors and networks from other components. This simplified network representation includes diverse, differentially interacting components and factors that unfold sequentially or concurrently over the lifecourse. Chronic disease outcomes result from interactions between the *chronic disease exposome* and the genome.³³



This evolving, though pragmatic, exposome-based epistemological framework enables us to collect comprehensive epidemiological data that more fully represent and potentially more accurately explain diverse chronic disease challenges. Omission of measures that assess factors such as those included in this heuristic representation could present a distorted picture of potential chronic disease etiology. This framework can clearly improve the quality of acquired data and reduce possible bias, which can ultimately increase the validity of results and subsequent effectiveness of related actions. Better data can clearly lead to more comprehensive findings as well as inferences that are more accurate.

Besides its potential contribution, the application of the emerging *chronic disease exposome* framework faces challenges,³⁴⁻³⁵ typical of observational and exposomic designs. Key among them relate to the collection, measurement, and analysis of large, heterogeneous, and complex data over long periods; assessment of causality amid multiple uncertainties; and logistical constraints as repeated collection of diverse biomarkers can be both costly and cumbersome. Evolving scientific and technological developments, along with commensurate funding, can, however, provide solutions to largely offset several of these perplexing challenges (e.g., integration of diverse data can be mitigated by leveraging advances in big data analytics and machine learning).³⁶⁻³⁷ Yet, given these challenges, the adoption of a pragmatic *chronic disease exposome* appears to be a promising step forward as even its partial characterization can bring enhancements to chronic disease research. Especially if we take advantage of high-resolution mass spectrometry and biobanked samples from population and occupational health studies, and leverage diverse available population-level geospatial data, such a practical *chronic disease exposome* approach can contribute to gradually enhancing what we already know about the exposome while restoring balance to the “*genome x chronic disease exposome*” equation.³³

Finally, in the context of related calls for comprehensive frameworks in chronic disease research,²⁹ the “public health exposome,”³⁸ “social exposome,”³⁹ and chronic disease-specific

exposome frameworks⁴⁰ also highlight the importance of holistic approaches to chronic disease. Yet, while both the “public health exposome” and “social exposome” emphasize the contribution of combinations of social, structural, and environmental exposures in explaining health challenges, neither incorporates a detailed conceptualization of work in the context of contributing exposures. On the other hand, chronic disease-specific exposome frameworks (e.g., focusing on cardiovascular diseases) shed light on the overlooked interplay among social, natural, and built environment exposures in delineating chronic disease risks and states, beyond conventional risks, but, again, work remains largely underrepresented. The *chronic disease exposome* intends to cover this gap with the introduction of a holistic epistemological framework that substantively integrates the whole of work in the potential etiological universe, enhances epidemiological data, and eventually improves inferences.

Steps forward

We have initiated an epistemological discourse on the rationale for the inclusion of more comprehensive *work-related* data, along with other behavioral, social, environmental, and biological data, in chronic disease epidemiology conceptualizations, designs, and models. Because current inadequacy, inaccuracy, or omission of comprehensive *work-related* measures can distort chronic disease epidemiological reality and potentially lead to inaccurate inferences, we build on and expand our *working life exposome* research and introduce the emerging *chronic disease exposome* that promises to make significant contributions toward this direction. This framework could also influence workplace policies, guiding employers to adopt more health-conducive practices that mitigate risks. The roadmap toward this direction requires a rigorous process that can gradually lead to the painstaking mapping and decoding of the *chronic disease exposome*—similar to ongoing efforts to sequence the overall exposome. Policy makers could also encourage the inclusion of *work-related* variables in national surveys to improve the accuracy of health interventions. Collaboration between epidemiologists, community health experts, and data scientists will be crucial in refining and applying this framework. Finally, despite challenges, an empirically validated *chronic disease exposome* can lead to overall better data and more accurate inferences in chronic disease epidemiology. This framework represents a significant advancement in our ability to understand and mitigate the impact of work on chronic disease, paving the way for more targeted and effective actions.

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