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Cohort Profile

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Cohort profile: The Boston Hospital Workers Health Study (BHWHS)

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Why was the cohort set up ?

Protecting and promoting the health of hospital workers is both an occupational health priority and a public health imperative. Health care workers are the fastest-growing segment of the US labour force.[1,2] Their working conditions present many health risks, which can affect them, their families, their patients and their employers.[3–6]

Though hospitals routinely collect employee payroll, injury, health and survey data, these databases are seldom integrated with each other and are rarely available to researchers outside the organization. This disconnect impedes efficient and organizationally relevant occupational health research and evidence-based practice regarding this high-priority workforce.

To address that gap, the Boston Hospital Workers Health Study (BHWHS), established in 2006, integrates several employee databases with worker surveys in two large hospitals that are part of the same health system. BHWHS resulted from a partnership between the Harvard T.H. Chan School of Public Health [National Institute for Occupational Safety and Health (NIOSH)-funded Centre for Work, Health & Well-being (hereafter referred to as 'the Centre')] and two academic and teaching hospitals that are part of Partners HealthCare (hereafter referred to as 'Partners'). The BHWHS is funded by NIOSH and is based in Boston, Massachusetts, USA.

BHWHS was created as a way for both the Centre and Partners to mutually advance their research and practice goals. At the study's inception in 2006 (systematic enrolment of new employees into the database was not fully realized until 2009), Partners was adopting more data-driven practices to inform decision making on organizational change, including the occupational health department. As a result of the changing focus, Partners created sophisticated employee databases. Concurrently, the newly formed Centre aimed to increase the evidence for a more holistic approach to occupational safety and health, by integrating traditional worker health protection functions with other worker health promotion and disease prevention activities.[7] Partners provided a rich source of data that could address the Centre's core research questions around work organization, worker health and safety, and integration of health protection and promotion activities locally. The Centre provided Partners with the

opportunity to have employee data analysed by occupational and social epidemiologists to inform policy and practice at the hospital. With this alignment of incentives, the chief of occupational safety and health at Partners (D.H.) and the principal investigator of the Centre (G.S.) formed a partnership to create the study. A key feature of the BHWHS continues to be close collaboration between Partners and Centre; Partners investigators (D.H. and K.H.) are full intellectual partners and co-investigators on the study.

BHWHS consists of a longitudinal, multidisciplinary database that integrates existing employer data with surveys of a subset of workers. Data are linked temporally at the individual and work-group levels. Using precise dates within each dataset, the team can conduct analyses of time-varying exposures and outcomes.

The research questions for the BHWHS have evolved over the three funding periods of the Centre. For the first two periods, from 2007 to 2011 and from 2011 to 2016, the BHWHS aimed to determine the factors in the work organization and environment that increased risk of musculoskeletal disorder (MSD) symptoms and risk-related health behaviours and, through pilot interventions, to estimate the feasibility and efficacy of integrated policies, programmes, and practices that reduce these risks. In the current phase (2016–21), the research questions relate to the role of the work organization in shaping outcomes for workers, patients and the employer.

Who is in the cohort?

Overall study

BHWHS is a prospective cohort study. All employees at the two hospitals who are classified as 'patient care services' workers are automatically enrolled in the cohort and are followed throughout their tenure. If employment is terminated or employees leave, their data remain in BHWHS; if they are re-hired, their original record is re-opened. Thus, the number of participants in BHWHS grows annually even as the number of active employees remains relatively stable (Figure 1). As of 2017, the cohort has 8200 active employees and 15 965 total employees. The study has been approved by the human subjects committee at Partners. Because all patient care services workers are automatically enrolled in BHWHS, participation is 100%, and attrition or loss to follow-up takes place only through employment separation.

BHWHS has a natural multilevel structure with the patient care unit as a critical organizational feature. Each unit has its own subculture with its own leaders and a consistent set of workers. Across the two hospitals, workers are nested within 106 units. Our data allow us to group workers to their assigned unit, which allows us to evaluate the impact of both individual- and unit-level factors on outcomes. Social and demographic characteristics of BHWHS participants have remained stable over time (Table 1).

Survey subsample

A subset of BHWHS workers are periodically sampled and asked to complete surveys to measure constructs not available in the employee databases. These survey responses are linked to BHWHS administrative data at the individual worker level. Thus far, three surveys have been completed (in 2009, 2012 and 2014) and a fourth is planned for 2018 (Table 2).

The initial survey (2009) was a random sample of employees. Beginning with the 2012 survey, the study follows a second random sample of workers longitudinally while also refreshing the sample with workers randomly selected at each wave. Refreshing the sample mitigates healthy worker survivor effects[8] and makes for a sample that is more reflective of the distribution of organizational tenure within the hospitals.

For the survey, sampled workers are invited to participate via e-mail and are offered a gift card as an incentive to complete the survey electronically. E-mail reminders are sent to non-respondents at prescribed intervals, and paper versions are thereafter sent to non-respondents. All workers provide informed consent before survey participation: see Table 2 for survey response rates and Table 3 for worker characteristics at each survey point.

How often have they been followed up?

Employee data on current study participants are updated quarterly or annually by the data manager (T.O.) from each of the Partners data sources; the data sources themselves accrue data continuously. As all records within each dataset are dated, once the sources are integrated within the BHWHS database, each employee has complete longitudinal data for the period in which they are or were employed.

Table 4 presents characteristics of those who have remained, left and joined the hospital workforces over the years. Among those who were employed in 2009 (study inception), those who left the workforce between 2010 and 2016 are roughly the same age as those who remained (respective birth years 1969 versus 1968). However, those who were hired between 2010 and 2016 and remain employed are younger on average (mean birth year 1984) than those who were hired during this period but left (mean birth year 1976). Among those in the baseline cohort who left, 13% retired, 43% separated either voluntarily or involuntarily, less than 1% died and the rest are unknown. The proportion of 'unknown' terminations

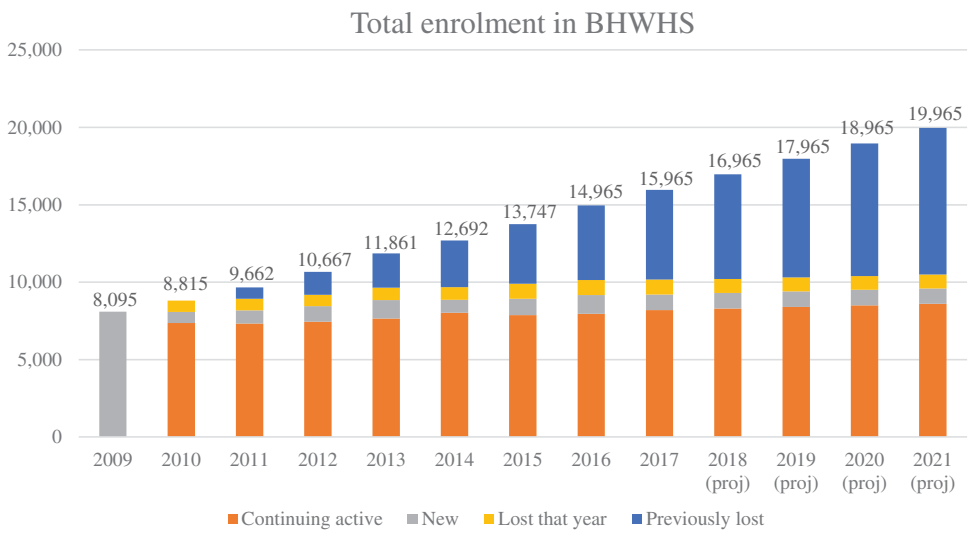

Figure 1. Number of participants in BHWHS, from 2009-present and projected through 2021. 'Continuing active' refers to workers who remain employed since the previous year, 'new' refers to workers added to BHWHS that year, 'lost that year' refers to workers who separated from the employer during that year, and 'previously lost' refers to workers who in past years have separated from the employer but nevertheless remain in the database. Workers accruing in the latter category over time drives the year-over-year increase in cohort size. (see separate file for figure).

Table 1. Social and demographic characteristics of active members of the BHWHS database at baseline and in 2016, using data from the human resources portion of the database

	2010 ($n=8076$)	2016 ($n=9172$)
Mean age	41	41
Sex		
Male	840 (10%)	1014 (11%)
Female	7236 (90%)	8158 (89%)
Job title[a]		
Nurse	5114 (63%)	5836 (61%)
PCA	1178 (15%)	1278 (13%)
Other	1800 (22%)	2465 (26%)

[a]One employee can have multiple job categories for the year if they change jobs during the year or work two different jobs, so the sum here is slightly different than the overall total.

PCA, patient care associate.

increased from those employed at baseline to those leaving during the next 6 years and is a limitation of the administrative data.

What has been measured?

Participant data for the BHWHS integrates existing hospital databases (Table 5), including employee occupational health services records, human resources, payrolls and employee health care use. As BHWHS has grown, the study team has developed partnerships across the hospitals to add additional types and sources of data. For example, the health system is self-insured, with a third-party provider acting as the group health plan. Through this arrangement, the hospitals have access to de-identified data on plan members' use and expenditures which has become part of

Table 2. Response characteristics and rates for periodic survey subsamples

	2009	2012	2014	2018 (planned)
Sampled	2000	2133	1968[a]; 1840 longitudinal, 128 new	2800 (est.)
Completed	1572	1595	Overall 1409; 1301 longitudinal, 108 new	TBD
Response rate	79%	75%	Overall 72%; 71% longitudinal, 84% new	TBD
Type of sampling	Cross-sectional	Cross-sectional	Longitudinal from 2012 + 128 new participants	Cross-sectional + follow-up of longitudinal participants[b]

[a]At the time of the 2014 follow-up survey, 287 members of the original survey cohort no longer met the eligibility criteria and were not included.

TBD, to be decided.

[b]Random sample of 2000, plus follow-up of still-eligible longitudinal participants not captured by random sample (estimated n=800).

Table 3. Social, demographic and occupational characteristics (*n*/percent) of the subset of workers who were surveyed at each wave. Note that 2009 was a cross-sectional survey. Starting in 2012, workers were followed longitudinally and the sample was refreshed with newly hired workers in 2014. Due to missing data on some variables, not all categories sum to the overall *n*

	Surveyed in 2009 ($n = 1572$)	Surveyed in 2012 ($n = 1595$)	Surveyed in 2014 ($n = 1409$)
Age (mean/SD)	41.3 (11.7)	40.9 (11.9)	41.5 (11.9)
Sex			
Male	143 (10%)	112 (7%)	89 (6%)
Female	1369 (90%)	1462 (93%)	1298 (94%)
Race/ethnicity			
Non-Hispanic White	1185 (79%)	1273 (81%)	1122 (80%)
Non-Hispanic Black	159 (11%)	136 (9%)	109 (8%)
Hispanic	65 (4%)	64 (4%)	55 (4%)
Mixed race/other	89 (6%)	107 (7%)	112 (8%)
Job title			
Staff nurse	1103 (70%)	1321 (83%)	1207 (86%)
Patient care associate	127 (8%)	141 (9%)	142 (10%)
Other	335 (21%)	129 (8%)	56 (4%)

SD, standard deviation.

Table 4. Characteristics of workers remaining in the cohort and those lost to follow-up, using data from the human resources portion of the database

	Employed continuously 2010-16 ($n = 4496$, 56%)	Original cohort members who left 2010–16 ($n = 3599$, 44%)	Hired between 2010 and 2016, remain employed ($n = 3626$, 56%)	Hired between 2010 and 2016 and left ($n = 2886$, 44%)
Birth year	1968	1969	1984	1982
Percent female	92%	87%	87%	83%
Reason left	–		–	
Retired[a]		452 (13%)[a]		23 (1%)[a]
Terminated		1539 (43%)		1262 (44%)
Died		30 (<1%)		2 (<1%)
Unknown		1578 (44%)		1589 (55%)

[a]Including those who terminated for unknown reason but were born before 1950, so we assume they have retired.

BHWHS (2010 and onwards). Currently, the Partners team is working with administrators at both hospitals to add data on patient outcomes such as adverse clinical events, length of stay and patient incidents, with the hope of temporally linking such data to the conditions of work on the unit where patients were treated.

The periodic worker survey measures worker perceptions of organizational policies and practices, features of the psychosocial work environment, worker health behaviours and worker characteristics (Table 6). Most measures are based on validated instruments, although some were developed by the research team.

What has it found? Key findings and publications

BHWHS studies are rooted in a common conceptual model in which the conditions of work are central determinants of workers' proximal and distal health outcomes as well as enterprise outcomes[9] (Figure 2).

Several themes have emerged from the findings. The first theme is that injury and musculoskeletal pain are rooted in the conditions of work, in terms of both work organization and workplace psychosocial environment.[10–19] The second theme is that the psychosocial work environment—including supervisor support, work-family conflict, job flexibility, scheduling, harassment and work organizational factors—shape safety and health behaviours and downstream health outcomes.[12–14,16,20–27] The third theme is that health behaviours have origins in the conditions of work, suggesting that working conditions need to be addressed in order for worker health behaviours to change.[23–26,28,29] The final theme of our findings is that, in a hospital setting, the workgroup or unit is a key unit of analysis and intervention,[13,14,21] but that interventions are most effective in changing behaviour when messages come from the highest levels of the organization.[30,31]

Table 5. Sources of administrative data in BHWHS and key variables that have been created or constructed from those data

Source	Type of data	Key variables created or constructed from data
Occupational health services	Occupational injury	• Injury timing, location, type, body part, nature, cause (including patient violence incident reports) • Days away from work; worker's compensation costs (medical care utilization, indemnity claim litigation)
Employee health insurance[a,b]	Health care use and expenditures	• Prescriptions and associated costs • Physician visits and inpatient care by diagnosis and associated costs • Mental health, allied health, physical and occupational therapy
Human resources	Demographics.work hours	• Paid hours of work, overtime, benefits • Sociodemographic worker characteristics • Date of hire, date left employment
Patient acuity	Workload	• Number of patients per unit (hourly data available) • Acuity of patients • Number and mix of nurses and PCAs working
Employee scheduling and payroll[a]	Days and times worked	• Exact time and place scheduled and shifts worked • Absenteeism and whether scheduled • How shift was paid and by whom (paid, unpaid, sick, vacation, call)

[a]Use of these data is restricted to computers within the Partners network.
[b]Available only for employees who are members of the hospital's group health insurance plan.

Table 6. Categories of variables and specific constructs measured by the periodic surveys of subsamples of the larger BHWHS cohort

Category	Constructs measured
Worker health and well-being	Musculoskeletal symptoms and functional limitations,[34] pain severity,[35] self-reported injuries, work limitations,[36] psychological distress,[37] job satisfaction,[38] self-reported chronic health conditions, self-reported height and weight
Worker health behaviours	Physical activity,[39] dietary patterns,[40] sleep,[41] self-efficacy to maintain healthy behaviours
Organizational policies and practices	Safety practices,[42] ergonomic practices,[42] people-oriented culture,[42] flexibility,[43] safe patient-handling norms, break practices, meal breaks,[43] shift scheduling and control[21]
Psychosocial occupational exposures	Supervisor support,[44] coworker support,[18] harassment,[45] bullying[46] job demands and control[44]
Physical occupational exposures	Self-reported injuries,[18] physical activity at work,[29] safe patient-handling practices[20,31]
Social, occupational and demographic worker characteristics	Age, gender, race, job title, immigrant status, family characteristics, financial distress,[47] hours worked, shifts worked

One of the many studies to emerge from BHWHS which highlight its capacity to illuminate the relationship between workplace factors and worker health, is a programme evaluation of hospital-wide safe patient-handling initiatives undertaken by one of the hospitals and analysed by the BHWHS team.[31] In an analysis using the non-intervention hospital as a comparison group, workers' self-reported ergonomic practices and safe patient-handling practices at the intervention hospital improved between baseline and follow-up (survey data), as did laundry services' weekly reports of laundered slings used for patient lifting (integrated database). Additionally, comparing the intervention with the comparison hospital and using the injury database, we observed lower odds of lifting/exertion injuries [post-intervention odds ratio (OR) 0.73, 95% confidence interval (CI) 0.60, 0.89] and neck/shoulder injuries (OR 0.68, 95% CI 0.46, 1.00).

BHWHS has also been used to highlight health disparities. Another study[18] compared workers' self-reported injuries in the survey with injuries found in the

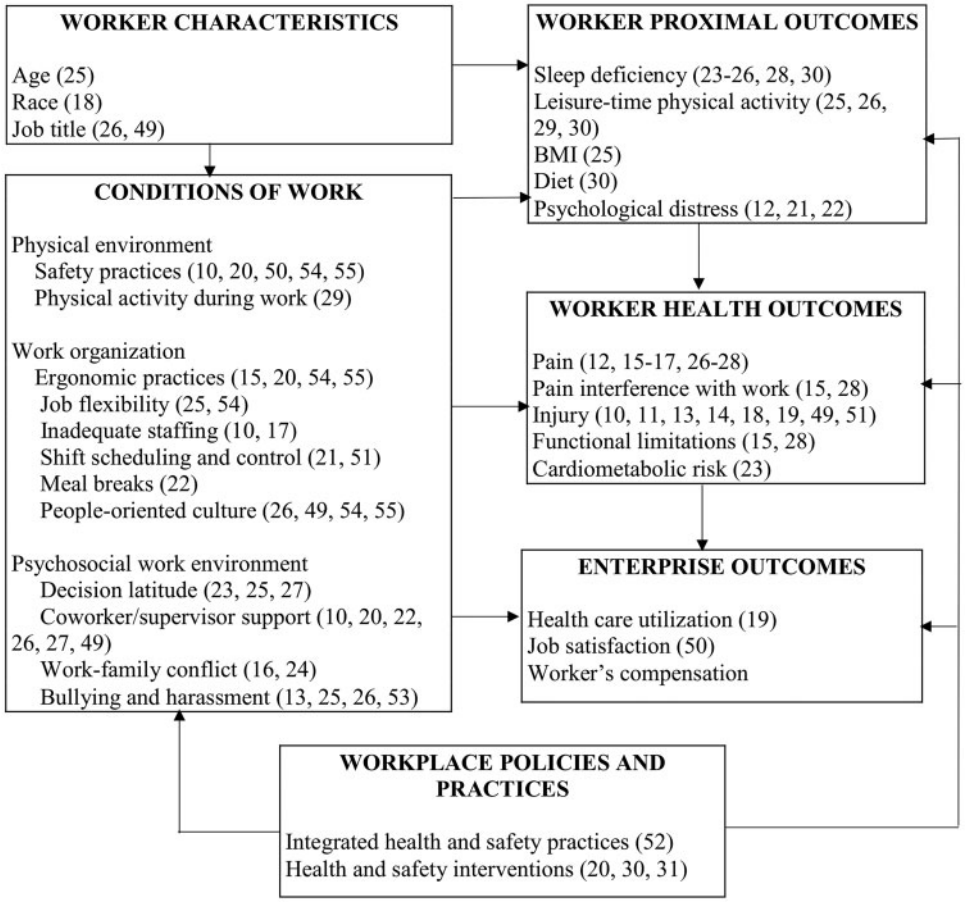

Figure 2. Conceptual model for BHWHS[9,48] with citations for BHWHS studies that have tested the given pathways (see separate file for figure).

administrative database, to test whether injury under-reporting occurred differentially by racial and ethnic group. The survey asked workers whether they had been seriously injured during the past year; researchers then searched the database for injuries for each worker in the year preceding the date they completed the survey. The study found that Black workers had greater odds (OR 1.91, 95% CI 1.04, 3.49) of self-reported injury than White workers, but no greater odds (OR 1.22, 95% CI 0.52, 2.77) of administratively-reported injury than White workers. This finding suggests that Black workers may systematically under-report their injuries, and thus administrative injury databases—upon which policies are often made—may not capture disparities.

A third study tested whether some of the medical expenditures related to workplace injuries were borne by group health insurance rather than by workers' compensation.[19] At the individual worker level, the study merged: data on occupational health services and data on injuries; health care use data on total outpatient health expenditures before and after injury; payroll and staffing data to develop denominators; and human resources data for demographic information. The study compared injured workers with workers who were not injured, controlling for pre-injury expenditures, age and job category. Injured workers had USD $587 (95% CI 167, 1140) more in non-workers' compensation health expenditures in the 6 months following injury than their non-injured peers.

What are the main strengths and weaknesses?

The main strength of BHWHS is its innovative creation of an integrated health and safety database of employees and their work environment. This results from the shared mission of the Centre and Partners, which is specific to this cohort (and thus may be difficult to replicate). Several practices have facilitated that relationship. The database is physically housed at Partners and is managed by a Partners employee (T.O.) who is partially funded by the study grant and is jointly supervised by investigators at Partners and the Centre. All data are de-identified and the team has honoured Partners' request that the most sensitive data remain on hospital networked computers for analysis. There is

close collaboration between the human subjects committees at Partners and the Harvard T.H. Chan School of Public Health, with each institution ceding review to the other at points; currently, the primary protocol is housed at Partners. All these factors build trust between various departments at Partners and the BHWHS team, which in turn has led to the addition of more sensitive information, such as the health expenditures data, to the database. Communications with the managers of all database components at Partners is handled exclusively by the Partners investigators on the study team (D.H. and K.H.), to further build those relationships and control study-related demands on those managers' time and effort.

Over time, the relationship between the Centre and Partners has led to a true intellectual partnership between the two groups. Partners investigators (mainly D.H. and K.H.) attend and participate in all BHWHS team meetings. They contribute substantively to all manuscripts that come out of BHWHS, and thus are co-authors. The Centre's close communication with the Partners team permits analysis of programmes, policies and practices already taking place at the hospitals,[31] a mutually beneficial arrangement. For example, the team's surveys in 2012 and 2014 were timed to occur before and after a safe patient-handling initiative being planned by one of the hospitals, independent of BHWHS.[31] The robustness of that study design would not have been possible without established channels of communication between the study team and the occupational health department.

The Partners team brings disciplinary perspectives that complement those of the Centre team. D.H. is an occupational medicine physician and a law professor, and thus contributes expertise in both policy and occupational health practice. K.H. holds a doctorate in environmental health and is an occupational health nurse; her research focuses on nursing organization and practice. Both K.H. and D.H. contribute substantive knowledge around patient care, health insurance, occupational health practice and the structure and culture of the hospitals.

The two groups engage in joint priority-setting, in which the Partners collaborators bring to the BHWHS team issues that are of particular interest to the two hospitals (e.g. bullying, mental health of employees) because those issues are likely of interest to other hospitals as well, increasing utility of findings. Researchers also share with Partners the research questions they are planning to ask in a given funding cycle, and Partners investigators provide feedback on how to make those questions most salient to current hospital concerns.

Methodologically, the study has several strengths that differentiate it from other occupational health studies. The size and breadth of this database are rare.[32,33] The automatic enrolment of participants—with careful de-identification to protect human subjects—captures all patient care workers with less selection bias and loss to follow-up than traditional cohort designs. The study enables multilevel analysis by linking individual and work-group data. With its longitudinal design—as of 2018, 10 years of data and counting—we can test complex hypotheses and account for temporal ordering of exposures and outcomes. The breadth of the database is supplemented with surveys. Furthermore, given that workers are clustered within units and many factors measured with the survey inherently occur at the group level, we can measure both group- and individual-level determinants of health.

The study does have limitations. The biggest is external validity; the very fact that the health system collects such detailed data on everyday operations, and that they wish to have such data analysed and published, is an indicator of an unusual employer. Other weaknesses are that survey data are available only on a subset of workers overall, in a smaller subset of workers longitudinally and at inconsistent time intervals.

Can I get hold of the data? Where can I find out more?

Because many of the datasets contain sensitive employee information, the study team maintains tight control of the data and its distribution. As with many occupational cohorts, the data cannot be made open access. However, the team is open to partnering with external collaborators who can travel to Boston and use the data on site. Those interested can contact the study principal investigator, Dr Erika Sabbath, at [erika.sabbath@bc.edu] for further discussion and to obtain an application. Certain data, namely the health claims and payroll data, are restricted to computers in the Partners network and cannot be distributed to external collaborators. Additionally, all manuscript proposals must be submitted to the BHWHS publications committee and approved by both Centre and Partners investigators before data analyses can commence.

Although the data have restrictions in how they can be distributed, our database serves as a model of the public health benefits of data collaborations between researchers and employers. This cohort profile serves as a guide to other researcher-employer teams looking to establish a similar database and collaboration, and the BHWHS team is available for further consultation to such teams.

Profile in a nutshell

- The Boston Hospital Workers Health Study (BHWHS) is a longitudinal, integrated open cohort consisting of employer data and survey data on approximately 16 000 hospital-based patient care workers aged 18-72, based at two hospitals in Massachusetts, USA.
- It represents an employer-researcher intellectual partnership between Partners HealthCare, and the Harvard T.H. Chan Centre for Work, Health, and Wellbeing.
- Data include individual-level, employer-provided data on health care spending, workplace injury, staffing, human resources and workload, and survey data on a subset of workers (on working conditions, self-reported health conditions and health behaviours).
- Workers are grouped into work-groups or units, allowing multilevel in addition to longitudinal analyses.
- Although the data are restricted in how they can be distributed (although the team is open to collaboration from outside researchers), the BHWHS is a model of the public health benefits of data collaborations between researchers and employers. This cohort profile serves as a guide to other researcher-employer teams looking to establish a similar database and collaboration.

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