Impact of Hawthorne effect on healthcare professionals: a systematic review

Woo Jin Choi (MD)*[1,2]; James J. Jung (MD)*[1,2]; Teodor P. Grantcharov (MD PhD)[1,2]

* Authors contributed equally to the manuscript
[1]Department of Surgery, University of Toronto, Toronto, Ontario, Canada
[2]International Centre for Surgical Safety, Keenan Centre for Biomedical Science, St. Michael's Hospital, Toronto, Ontario

Abstract

Background and Aims: The Hawthorne effect – the alteration of behavior by subjects due to their awareness of being observed – is evident in both research and clinical settings involving different forms of observation. However, the role of the Hawthorne effect on healthcare professionals and their practice are poorly understood. A systematic review of primary studies that examined the role of the Hawthorne effect on healthcare professionals was performed.

Materials and Methods: MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials, PsycINFO, and CINAHL were searched. Studies that discussed any changes in healthcare professionals' performance or behavior due to observation or awareness of being studied were included. A quality assessment tool for observational cohort and cross-sectional studies was used to assess risk of bias. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used to report this review.

Results and Conclusions: In total, 23 studies were analyzed. 18 out of 23 (78%) studies showed behavioral change among observed healthcare professionals, and all behavioral changes led to increased productivity, compliance, or adherence to best practice guidelines or protocols. From 13 studies that observed only physicians as subjects, 8 (62%) studies reported a positive Hawthorne effect. 86% of studies using "direct" observation methods demonstrated positive Hawthorne effect in comparison to 67% using "indirect" observation. Of the five studies with post-intervention follow-up, four studies (80%) reported either diminished or decreasing Hawthorne effect within three months once observation ceased. Of the three studies with continued observation, two studies reported diminished Hawthorne effect. This systematic review demonstrated that healthcare professionals were affected by the Hawthorne effect. They tended to exhibit short-lived positive behavior change when observed.

Introduction

The term "Hawthorne effect" originates from a series of experiments assessing productivity in the 1920's.[1] These studies demonstrate that observation of the work environment induces behavioral changes among workers to perform their tasks more efficiently.[1] Controversy with regard to the fundamental mechanism of Hawthorne effect still exists.[2-4] However, it has increasingly been accepted as a potential confounder in research studies involving any forms of observation.[5-15] Despite the growing relevance, consequences of the Hawthorne effect on healthcare professionals have not been widely studied.[16] A study conducted by McCambridge et al. reviewed available studies that reported on Hawthorne effect at the time, however the search criteria was limited to the term "Hawthorne effect," capturing only six studies specific to healthcare professionals that were heterogeneous.[5]

Several studies suggested that the Hawthorne effect could influence healthcare professionals and the care they provide.[3, 5, 10, 17-19] For instance, a placebo-controlled clinical trial suggested that when patients with mild to moderate dementia were treated with Ginkgo biloba, they had better outcomes on intensive follow-up than on minimal follow-up.[19] While two-thirds of the healthcare providers in this study reported no preference in the frequency of follow-ups, the intensive follow-up care providers may have exhibited a better recognition of the patients' needs, improving the overall doctor-patient relationship and care.[19] Another study reported that visits to general practitioners by peers led to improvement in several aspects of their medical practice, such as record keeping, patient referrals, and medical equipment availability.[20] Similarly, the presence of audio-recording tools in medical offices induced a positive change in antibiotic prescribing practice.[21] Whether these behavioral changes were the result of physicians' discomfort, perceived demand for improved performance or awareness of the study intent, the impact of the Hawthorne effect in clinical practice is evident.[20-23] However, the reported characteristics of the Hawthorne effect in healthcare professionals and how it might influence the care they provide is unclear. [5,21]

Corresponding Author:
Dr. James J. Jung
jungj@smh.ca

The objective of this paper was to systematically review primary studies that investigated the Hawthorne effect or any observational effects on healthcare professionals. We first described the consequences of the Hawthorne effect on healthcare professionals by narratively summarizing direction (e.g. positive or negative) and duration of behavioral changes. The secondary objective was to examine whether the consequences of Hawthorne effect differed with varying observation methods, subjects, and study designs. Our study aimed to provide the most up-to-date evidence on the existence of the Hawthorne effect and consequent behavioral changes that might occur among healthcare professionals.

Materials and Methods

Search Strategy

MEDLINE, Cochrane Central Register of Controlled Trials, PsycINFO, CINAHL and EMBASE were searched from inception to June 2016 to identify all relevant studies. A detailed search protocol is included in Appendix 1. We used topics and keywords specifying observer effect (i.e. Hawthorne effect) and healthcare professionals (e.g. physicians, paramedics, nurses) to facilitate a wider search. References of the included studies were manually searched for additional studies. We manually searched the first 100 hits from Google Scholar for augmenting studies and used EndNote X7 software (Reuters, New York) to store the included studies and to remove duplicates. We reported this systematic review in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline.[24]

Inclusion and Selection Criteria (Figure 1)

We included studies if they were peer-reviewed English-language studies and were original, empirical studies with the Hawthorne effect being the primary or secondary outcome. Studies that discussed healthcare professionals' performance or behavior in any relation to observation or awareness of being studied were included. Studies that reported incidental findings of the Hawthorne effect in the control arm were also included. Titles and abstracts of the identified studies were screened for relevance to our objectives. Two independent reviewers (WC and JJ) reviewed full-text articles for eligibility. Any disagreements between the two reviewers were discussed, and if no consensus was reached, a third member (TG) made the decision for inclusion.

Assessment on Risk of Bias and Methodology Quality

Two independent reviewers (WC and JJ) conducted assessments on risk of bias and methodology quality of the final, included studies. A quality assessment tool for observational cohort and cross-sectional studies developed and reviewed by National Institutes of Health[25] was used. Studies that were rated "poor" were excluded from further analyses. There were no randomized controlled trial studies to be assessed. Details of the quality assessment tool criteria are presented in Appendix 2.

Data Extraction

Data extraction from the included studies was performed using a piloted, standardized template designed by the research team. The data were maintained in Microsoft Excel (Microsoft, WA).

Results

Study Selection (Figure 1)

Our initial search strategy identified a total of 766 articles. Of these, 164 studies were removed as duplicates. After initial title and abstract screening, 457 abstracts were excluded for not meeting our inclusion criteria. A total of 147 full-text articles were screened, of which 122 articles were excluded. Reasons for exclusion are demonstrated in the PRISMA flowchart (Figure 1). Twenty-five studies were included for analysis.[21-23, 26-45]

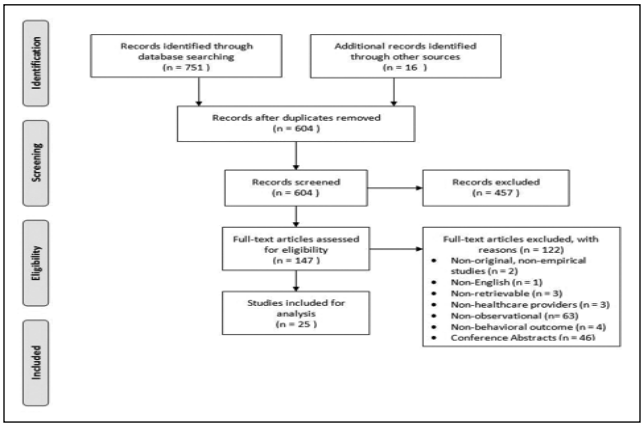

Figure 1. PRISMA Flowchart

Assessment on Risk of Bias and Methodology Quality

Quality review assessment results are presented in Appendix 2. Using the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies developed by National Institutes of Health, four studies were rated as "good" and 18 studies were rated as "fair". Two studies were rated as "poor" and excluded from the final inclusion studies.[46,47] Thus, a total of 23 studies were subjected to further analysis and their results are presented in Tables 1 and 2.

Study Characteristics (Tables 1 and 2)

The characteristics of the 23 studies are summarized in Tables 1 and 2. All 23 articles were prospective studies published from 1976 to 2016. Fourteen studies (61%) had human observers or "direct observation" methods and nine studies had non-human observers or "indirect observation" methods.[22,23,26-30,32,33-39,40-45] Thirteen studies (56%) observed physicians only, and the remaining ten studies observed a mix of hospital staff including physicians, nurses, medical students, and hospital technicians.[21,22,28,30-34,38,39,42,44,48] Nine studies (39%) were conducted in academic hospital settings, seven in non-academic hospital settings, and seven studies did not specify. Duration of studies ranged from two days to 1520 days. Outcome measures were specific to each study presented in Table 2. Seven studies specifically measured hand hygiene compliance rates as a consequence of the Hawthorne effect.[26,29,35-37,42,45]

Presence of Hawthorne Effect (Table 2)

18 of 23 (78%) studies showed behavioral change among healthcare professionals when they were observed.[21-23,26,27,29-31,34-39,41-43,45] All of these 18 studies (100%) demonstrated "positive" behavioral changes defined as increased productivity, compliance, or adher-

T**able 1**. Study Characteristics of Final Inclusion Studies

Author	Year	Journal	Study Type	Funding	Geography	Population	Setting
Bittner, et al.	2002	Infection Control and Hospital Epidemiology	Prospective	Unknown	USA	ICU staffs (all HCW entering patient room)	Hospital ICU
Campbell, et al.	1995	Annals of Emergency Medicine	Prospective	Public	USA	Paramedics	Emergency medical services system
Campino, et al.	2008	ACTA Paediatrica	Prospective	Public	Europe	Neonatologists, residents, RNs, and nurses' aids	Neonatal ICU (NICU)
Collar, et al.	2012	Journal of the American College of Surgeons	Prospective	Hybrid	USA	Otolaryngologists	Academic hospital operating room
Eckmanns, et al.	2006	Infection Control & Hospital Epidemiology	Prospective	Public	Europe	Physicians and nurses	Hospital ICU
Edwards, et al.	2013	Canadian Journal of Anesthesia	Prospective	Public	Other	Anesthesiologists	Academic hospital
Evans, et al.	2014	BMC Pregnancy & Childbirth	Prospective	Public	Other	Obstetricians and surgical providers including anesthetists	14 low resource facilities, 4 specialized, 3 regional, 7 provincial hospitals
Fernald, et al.	2012	Journal of the American Board of Family Medicine	Prospective	Public	USA	Primary care physicians	16 primary care practices in 2 health care systems
Fox, et al.	2008	European Journal of Obstetrics, Gynecology, & Reproductive Biology	Prospective	Unknown	USA	Obstetricians	Hospital labor and delivery unit
Gruber, et al.	2003	American Journal of Hospice & Palliative Care	Prospective	Public	USA	Internal Medicine residents	Academic hospital
Hagel, et al.	2015	Infection Control & Hospital Epidemiology	Prospective	Hybrid	Europe	All staffs in ICU (nurses, physicians, technicians, physiotherapists)	Academic hospital - 24 bed anesthesiological-surgical ICU
Harbarth, et al.	2002	Pediatric Infectious Disease Journal	Prospective	Private	USA	All healthcare workers in ICU (physicians, nurses, respiratory therapists)	ICU, tertiary pediatric hospital
Kohli, et al.	2009	Infection Control & Hospital Epidemiology	Prospective	Unknown	USA	Physicians, nurses, other hospital staffs	Academic hospital, 3 inpatient units
Lam, et al.	1997	Transfusion	Prospective	Unknown	USA	All physicians	Two matched, non-teaching hospitals
Leonard, et al.	2006	Social Science & Medicine	Prospective	Unknown	Other	Physicians	Outpatient clinics
Leurent, et al.	2016	BMC Infectious Diseases	Prospective	Unknown	Other	Prescribing health workers	Primary care facilities in rural district in Tanzania
Mangione-Smith, et al.	2002	Health Services Research	Prospective	Hybrid	USA	Pediatricians	Community practices
Miller, et al.	2015	PLOS one	Prospective	Public	Other	Ethiopian health extension workers	Rural Ethiopian practices
Pan, et al.	2013	PLoS One	Prospective	Public	Asia	All hospital staffs (physicians, nurses, others)	Academic hospital
Pittet, et al.	2004	Annals of Internal Medicine	Prospective	Unknown	Europe	Physicians	Large university hospital
Rheineck-Leyssius, et al.	1996	British Journal of Anaesthesia	Prospective	Unknown	Europe	Six anesthetists and nurses	Community hospital
Rosser, et al.	1976	Medical Care	Prospective	Public	Europe	Clinicians	Academic teaching hospital
Yin, et al.	2014	Infection Control and Hospital Epidemiology	Prospective	Public	USA	All ICU and medical surgical ward healthcare workers (clinicians, nurses, others)	Three distinct acute care hospitals

Abbreviations: HCW, Healthcare workers: ICU, Intensive care unit; NICU , Neonatal ICU; RN, Registered nurse

Table 2. Results of Observational Methods and Outcomes from Final Inclusion Studies

Author	Observation methods	Comparisons	Subject blinding	Sample Size	Duration of Study	Outcome Measures	Duration of Hawthorne effect	Summary of reported findings	Reviewer comments including on principal risks of bias
Bittner, et al.	Visible live-person observation and sustained graph display feedback	No live observation nor graph display feedback	No	17 patient beds and 8 sinks	6 months	Estimated hand washing episodes using towels and soap measurement	Once observation seized, mean outcome of 1.36 dropped to 1.01, 0.8, and 0.87 over 4 months	Transient Hawthorne effect shown in control group. When observer present (mean 1.36) vs. removed (mean 1.01, dropped to 0.8 over 4 months, and increased back up to 1.16 with observer present again).	Potential contamination of feedback between groups. different baseline level between two ICUs and risk of variation in indirect estimation of soap and towel consumption.
Campbell, et al.	Announcement of study on a memo	Baseline period prior to the interventions	No	145 paramedics and 30828 reports	9 months	Documentation rates of meds, allergy, and medical history	Unknown	Study led to increase in 2 of 3 recording outcomes (medications and allergy). p value and regression coefficients reported	Sequential intervention design, no evaluation of confounding variables. Different baseline and behavior changes for stratified sub-groups. Higher performing groups did not change.
Campino, et al.	Presence of a person reviewing and registering the drug records	Pilot phase: baseline drug error rate without any reviewer	No	11 neona-tologists, 5 pediatric residents, and 47 RNs. 122+4182 recordings	Unknown	Prescription and transcription error rates	Unknown	Reduction in prescription error rate from 32.8% to 19.2% in the pre-intervention study phase. p value reported. Rates of incorrect dosing and lack of dose specification dropped, but not transcription errors.	Reviewing process not concealed to the NICU staff during pilot phase. Doctors might have been more aware of the reviewer as longer work hours
Collar, et al.	Visible live-person observation by research members. workers made aware of performance efficiency measurement	No observation nor awareness of study	No	144 + 35 operative cases, 258 turnover and turnaround time points	9 months baseline and 3 month observer effect	OR turnover and turnaround time	n/a	No difference between the baseline and observer-effect periods of study for turnover time (p=0.98) or turnaround time (p=0.2)	Small scale of study, practice of one academic surgeon in a single specialty and scope of practice.
Eck-manns, et al.	Announced a 10 day direct observation study of hand hygiene compliance	Covert observational period 10 month prior to the study	Only during covert observation	2808 indications for antiseptic hand rub (AHR) use, 937 in period 1 and 1981 in period 2	10 days each period, 10 month apart	Observed use of AHR	Unknown	AHR compliance increased from 29% to 45% during the overt observation period (OR, 2.33; 95% CI:1.95,2.78; higher in multivariate model)	Big differences in indications for use in two periods reflects different observation procedures. Observer bias also possible.
Edwards, et al.	Intensified observation: Visible live-person observation by study personnel entering observation data into highly visible electronic tablets	Reduced observation period (towards end of the study, not necessarily present all the time and not entering obser-vation or work-load data)	No	69 anesthe-siologists with 400 records and 200 in each arm	11 months	Compliance score from completeness of records using 32 checklist modified from clinical guide-line	Unknown	Higher completion of text entries during the period of intensive intraoperative observation (87.3%) than subsequent period of less intensive observation (81.6%), mean difference 5.7%; 95% CI 4.2 to 7.3%I p<0.0001. More pronounce in handwritten records.	Accuracy not assessed, and not able to distinguish whether the changes is due to reduced observation or wearing off initial, intensified observer Hawthorne effect.

Abbreviations: HCW, Healthcare workers: ICU, Intensive care unit; NICU , Neonatal ICU; RN, Registered nurse, OR: Operating room, AHR, antiseptic hand rub; MRSA, Methicillin-resistant *Staphylococcus aureus*; SSTI, Soft tissue infections; EFW, Estimate of fetal weight; HHE, hand hygiene events; ICP, Infection control practitioners

T**able 2**. Results of Observational Methods and Outcomes from Final Inclusion Studies (continued)

Author	Observation methods	Comparisons	Subject blinding	Sample Size	Duration of Study	Outcome Measures	Duration of Hawthorne effect	Summary of reported findings	Reviewer comments including on principal risks of bias
Fernald, et al.	Participation in follow-up case reviews with research team and family physicians discussing guidelines and interventions	Clinicians who did not participate in follow-ups	No	91 primary care clinicians, 271 observed skin and soft tissue infections (SSTI) cases, 1135 comparison cases	6 months	Management of SSTI, including rates of incision & drainage, cultured abscess, prescription of antibiotics that covered MRSA (Methicillin-resistant *Staphylococcus aureus*)	n/a	No change in prescription of antibiotics or in selection of antibiotics that cover MRSA in the follow-up group. No higher rate of drainage procedures or cultured abscess	Small number of observed cases (21 abscess and 250 cellulitis). Lacks live-person direct observation during the patient visit and decision making moment.
Fox, et al.	Impact of awareness of being studied on measuring accuracy for estimate of fetal weight (EFW)	Accuracy of estimates found in consecutive equivalent records from an earlier period	No	187 in cases and 187 controls	Unknown	Differences in accuracy, proportions of EFWs falling into birth weight +/- 10%	n/a	No differences in main analysis (control 67.9% vs. study 68.5%, p=.96). Same result with subset of babies with birth weights >4000g but underpowered for analysis (control 37% vs. study 53%).	Equivalence problematic. Different clinicians in two periods of measurements.
Gruber, et al.	Surveyed residents using 0 to 10 scale to determine how well they assessed their patient's level of pain	Three weeks later, when no more feedback or surveys were being provided	No	4 residents in control group, assessing 61 times total	3 weeks	Accuracy of estimate of patients highest pain level in last 24 hours scaling from 0 to 10 (+/- 2 points within patients' answer)	At least 3 weeks	In the control group, rate of correct patient assessment increased from 42% to 70% after 3 weeks post-survey. $p < 0.05$	Small sample size. risk of contamination, and residents anticipating follow-up studies.
Hagel, et al.	Visible live-person observation	No observation and only using electronic dispenser count for measure	No	4180 events recorded by electronic dispenser and 2029 simultaneously with observer. Total 3978 observed events over 96 hours	3 months, 100 hours of observation	Mean difference in the number of hand hygiene events (HHE) per 2 hour period	Unknown	21 HHE /hr when observed vs. 8 HHE/hr when not observed. 5 HHEs/pt/hr vs. 2 HHE/pt/hr, respectively. linear model shown, 61% explained	Singe ICU setting. visitors using electronic dispensers were also counted. Equivalence problem as averaged total counts regardless of baseline per individual worker or team
Harbarth, et al.	Live-person observer, not previously known personnel	Baseline compliance measured at the beginning of study	Blinded to the real purpose of study	12216 total events recorded	1.5 months of baseline period with observation only	Compliance of hand hygiene recommendations	At least 2 weeks	Baseline compliance decreased from 42.5% to 28.2% after first 2 weeks of observation. The higher compliance rate in the beginning of the study is like the Hawthorne effect.	Additional intervention was introduced while compliance kept decreasing with the introduction of observation. No true baseline measured before the starting of observation.
Kohli, et al.	Visible live-person observation by known personnel or infection control practitioners (ICP)	Visible live-person observation by unknown personnel (student intern)	No	3 inpatient units, 332 hand hygiene episodes observed by 3 ICPs and 355 by student intern	4 months	Difference in rate of hand hygiene compliance between known and unknown observer, and magnitude of change in previously high vs. low performing unit	Unknown	ICPs observed significantly higher compliance rates in high performing units than did the student intern, whereas in the low-performing unit both measured similarly low rates of compliance.	Student observer was physically present during the covert observation.

Abbreviations: HCW, Healthcare workers: ICU, Intensive care unit; NICU , Neonatal ICU; RN, Registered nurse, OR: Operating room, AHR, antiseptic hand rub; MRSA, Methicillin-resistant *Staphylococcus aureus*; SSTI, Soft tissue infections; EFW, Estimate of fetal weight; HHE, hand hygiene events; ICP, Infection control practitioners

T**able 2**. Results of Observational Methods and Outcomes from Final Inclusion Studies (continued)

Author	Observation methods	Comparisons	Subject blinding	Sample Size	Duration of Study	Outcome Measures	Duration of Hawthorne effect	Summary of reported findings	Reviewer comments including on principal risks of bias
Lam, et al.	Self-audit forms and memo to all physicians explaining the study and starting date.	Control hospital got similar memo with transfusion guidelines but no information on research nor the self-audit forms	No	7 to 44 self audit forms per month	11 months	Number of blood units transfused per patient	3 months	Transient reduction in blood utilization in study hospital. p values reported.	Equivalence problem with different hospitals and group of clinicians. No live-person observations were conducted.
Leonard, et al.	Visible live-person observation of consultations by researchers	Non-observed consultations before research team arrival	No	12 clinicians, 320 patients	Unknown	Patient reported quality of care in post-consultation questionnaire	10 to 15 consultations	Patient-reported quality of care increased by 13% with direct observation and returned to pre-observation levels after 10 to 15 consultations. Duration of time not specified.	Both analysis and the reporting of outcome data are complex.
Leurent, et al.	Days when exit interviews followed after consultation by a exit survey interviewer	Days when consultations not followed by exit interviews	No	19579 consultations in 18 facilities	1520 days	Proportion of patients with a non-severe, non-malarial illness being prescribed an approved anti-malarial drug in a consultation for new illness	Unknown	No strong evidence of Hawthorne effect but overall better practice shown with exit interviews. More consultations recorded with more complete recording on survey days (significant p values). Three primary outcomes improved on survey days but not statistically significant. Hawthorne effect sustained.	Complex reporting.
Mangione-Smith, et al.	Impact of audio-taping consultations and completing questionnaires on inappropriate antibiotic prescribing	Unobserved consultations during the same time period and later on.	Blinded to the real purpose of study	10 pediatricians. 91 non-observed consultations, 149 observed	5 months and one 1 year later another 5 months	Antibiotic prescribing in viral cases under direct observation or in previous medical records	At least 1 year	Antibiotic prescribing rate in viral cases was 29% lower when observed than not (17% vs. 46%). 1 year later the rate sustained at 37% with no further observation, suggestive of sustained Hawthorne effect.	Differences in case-finding strategy. Study purpose likely known by the prescribers. Reporting complex
Miller, et al.	Visible live-person observation	No observation	No	246 observed by the survey team and 298 not observed	2 months	Estimates of indicators of quality of care	n/a	Difference relatively small for most of the indicators. Summary indicator of correct management of major illness 66% (observed) vs. 68% (non-observed). Borderline significant for only one indicator.	Small sample sizes and equivalence problematic

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T**able 2**. Results of Observational Methods and Outcomes from Final Inclusion Studies (continued)

Author	Observation methods	Comparisons	Subject blinding	Sample Size	Duration of Study	Outcome Measures	Duration of Hawthorne effect	Summary of reported findings	Reviewer comments including on principal risks of bias
Pan, et al.	Visible live-person overt observers (infection control nurses and physi-cians)	Covert observers (not previously known medical students)	Only during covert observation	23,333 hand hygiene episodes, 17742 by covert ob-server	1 year	Quarterly and annual hand hygiene compliance rate	Unknown	Overt observer detected significantly lower rates of compliance (44.1%) than full time covert observers (74.4, 94.1%) in a 1 year period. P-value significant.	No simultaneous comparison between covert vs. overt groups. Quarterly feed-back renews potential Hawthorne effect.
Pittet, et al.	Individual observation of physician hand hygiene followed by self-report questionnaire. Informed by mailing of the study.	Group who were also observed but self-reported not being aware of being observed	No	163 physi-cians and 887 hand hygiene episodes	6 months	Hand hygiene adherence and awareness of being observed or not	Unknown	Multivariable regression demonstrates that being watched is an independent predictor of better compliance	Subject self-report bias and no direct comparison group.
Rheineck-Leyssius, et al.	Explicit instruction to prevent and treat low SpO_2 and give aware-ness that they are being studied.	Pre-intervention phase, unaware of the data collection and no new instructions provided	Only in pre-intervention phase	data from 1350 patients, 450 in each arm	5 months	Incidence rate of hypoxemia	Four months or less	Incidence of hypoxemia significantly decreased from 17.8% to 11.6% (pre-intervention vs. intervention phase, $p<0.01$) In post-intervention period the level returned. Intra-operative care was also influenced with start of study	Sample size under-powers the phase 3 analysis. Cannot distinguish Hawthorne effect vs. the impact of explicit instructions.
Rosser, et al.	Steps taken to emphasize that utilization of hospital beds was under recording and monitored	Pre-intervention phase	No	Four internal medicine physicians	2 weeks	Percentage of hospital beds that could have been saved.	n/a	Hawthorne effect was negligible.	Did not conduct live-person direct observation.
Yin, et al.	Visible live-person observation by a covert researcher	n/a	During covert observation	11444 hand hygiene episodes observed, 3432 hours of direct observation	26 months	Hand hygiene compliance rates	At least 1 hour	Exit hand hygiene compliance increased after 14 minutes of observation (from 56.2% to 60.5%; $P < .001$) and increased further after 50 minutes (from 60.5% to 66.0%; $P <.001$). Entry compliance had highest HE after 38 minutes.	No baseline comparison arm that does not entail a live-person observer. Risk of underestimating Hawthorne effect.

Abbreviations: HCW, Healthcare workers: ICU, Intensive care unit; NICU , Neonatal ICU; RN, Registered nurse, OR: Operating room, AHR, antiseptic hand rub; MRSA, Methicillin-resistant *Staphylococcus aureus*; SSTI, Soft tissue infections; EFW, Estimate of fetal weight; HHE, hand hygiene events; ICP, Infection control practitioners

ence to best practice guideline or protocol. No "negative" behavioral change was observed. All 7 (100%) studies that measured hand hygiene compliance showed the Hawthorne effect. [26,29,35-37,42,45] Of the 13 studies that observed only physicians as subjects, 8 (62%) studies reported a positive Hawthorne effect and the other 5 (38%) studies reported no behavioral changes.[21,22,28,30-34,38,39,42,44]

Subject Awareness of Being Observed (Table 2)

There were three studies where subjects were not made aware of the fact that they were being observed for hand hygiene compliance by covert human observers.[29,41,45] However, all three studies (100%) still demonstrated positive behavioral changes and the authors attribute this to failed blinding of subjects.[29,41,45] Two other studies did not reveal the true purpose of the study (i.e. measuring observational effect) to their subjects.[21,36] Both of these studies also demonstrated a positive Hawthorne effect.[21,36] Of the 17 studies where the subjects were aware of being observed, 12 (70%) studies showed a positive Hawthorne effect.[22,23,26,27,30,31,34,35,37-39,42]

Observation Methods (Table 2)

Of 14 studies using "direct" observation methods, 12 (86%) studies demonstrated a positive Hawthorne effect.[22,26,27,29-31,35-37,41,42,45] Of 9 indirect observation studies, 6 (67%) studies demonstrated a positive Hawthorne effect.[21,29,36, 41,43,45] The following indirect observation methods were used: announcement of a research study to monitor medical document records, participation in follow-up case reviews or interviews with research team, conducting surveys in relation to specific aspects of patient care, distributing self-audit forms in relation to research, audio-tape recoding consultations, and providing explicit instructions on a medical guideline (Table 2).

Duration of Hawthorne Effect (Table 3)

Eight of 23 studies discussed the duration of Hawthorne effect.[21,22,26,34,36,38,43,45] Five studies specifically conducted post-intervention follow-up to measure the duration of Hawthorne effect after the observation ceased[21,26,34,38,43] (Table 3). Of the five studies with post-intervention follow-up, four studies (80%) reported either diminished or decreasing Hawthorne effect within three months. Three studies attempted to measure the level of Hawthorne effect while undergoing observation (Table 3).[22,36,45] Of the three studies with continued observation, two studies reported diminished Hawthorne effect.[22,36]

Discussion

The present systematic review demonstrates the existence of the Hawthorne effect among healthcare professionals. When the Hawthorne effect exists, it is short-lived. It likely leads to increased productivity, compliance, or adherence to standard protocols. Both direct and indirect observational methods can induce the Hawthorne effect. Physicians may be less frequently influenced by the Hawthorne effect, but are still exposed and it might affect their medical practice. Heterogeneity of the study methods in our systematic review prohibited meta-analysis, limiting us to a narrative review.

The results of our study suggest that behavioral changes in healthcare professionals are likely to occur with observation. Eighteen (78%) of the included studies showed some degree of positive Hawthorne effect, supporting the original findings of the Hawthorne Works study.[1,21-23,26,27,29-31,34-39,41-43,45] These studies demonstrated increases in context-based variables such as efficiency, compliance, or adherence (Table 2). In studies that assessed the observation effect in general population, there were mixed results, ranging from negligible, transient, to sustained Hawthorne effect.[6-9,15,23,26,28,31-34,36-38,43,44,48] The reason for not producing a consistent degree of the Hawthorne effect may stem from the heterogeneity in study designs with non-standardized definitions of observation and reporting methods.[46] Furthermore, there is some evidence that the Hawthorne effect might not follow a simple dose-response relationship.[5]

There are few studies that reported the duration of Hawthorne effect. In our review, four of the five studies that conducted post-intervention follow-up showed diminishing Hawthorne effect once the observation ceased[21,26,34,38,43] (Table 3). Additionally, two

Table 3. Reported Durations of Hawthorne Effect

Author	Observation method	Post-intervention follow up	HE Duration	Trend of HE	Measured outcome
Bittner et al.	Direct	Yes	4 months	Continued to drop[a]	Hand hygiene compliance
Gruber et al.	Indirect	Yes	At least 3 weeks[b]	Sustained with no further follow-up	Patients' pain level assessment
Lam et al.	Indirect	Yes	3 months	Returned to pre-observation level	Blood utilization
Mangione-Smith et al.	Indirect	Yes	At least 1 year	Continued to drop	Antibiotic prescribing in viral cases
Rheineck et al.	Indirect	Yes	At most 4 months[c]	Continued to drop	Incidence of hypoxemia
Harbarth et al.	Direct	No	At least 2 weeks[d]	Returned to pre-observation level	Hand hygiene compliance
Leonard et al.	Direct	No	10 to 15 consultations[e]	Returned to pre-observation level	Patient-reported quality of care
Yin et al.	Direct	No	At least 1 hour	Sustained with no further follow-up	Hand hygiene compliance

Abbreviations: HE, Hawthorne effect.
[a] Study ended prior to diminished effect; [b] Study ended at the 3 week mark; [c] Reporting not clear; [d] Study ended at the 2 week mark; [e] Not measured in relation to time

studies reported diminished Hawthorne effect while undergoing observation[22,36] (Table 3). This result is consistent with the recent evidence suggesting Hawthorne effect is likely short-lived in the general population, lasting for hours to weeks after observation is ceased.[5,6,22,36,38,39,49] Bittner et al. specifically reported that Hawthorne effect itself could not be a sustainable intervention tool for increasing hand hygiene compliance.[26] One study showed a sustained effect after the observation stopped, but the authors suggested it was likely due to the control group finding out the study intent.[34] Another study that reported sustained Hawthorne effect was limited to a one hour study design with no follow-up.[45]

Direct observation seemed to have induced the Hawthorne effect more commonly than indirect observation. This highlighted that when conducting a study where subjects were observed, the method of observation mattered. Hagel et al. reasoned that direct human observations were more likely to influence observer bias.[35] There were three studies that examined the effect of observation on hand hygiene compliance using covert observers and demonstrated positive bahaviour changes among the subjects.[29,41,45] The authors argued that despite the best efforts to hide the identity of covert observers, the subjects must have suspected their intention. In support, Harbarth et al. argued that sudden and frequent appearance of an unknown person could induce the Hawthorne effect.[36]

Although physicians are expected to meet the best practice guidelines regardless of being observed or not, 62% of our studies involving physician-only subjects still exhibited positive behavior changes when observed. The results of this review highlight that physicians are also susceptible to the Hawthorne effect, which may impact their medical practice.[21,22,33,34,38] Evans et al. suggested that observing surgeons might enhance their motivation for better performance.[31] On the other hand, a study that interviewed surgeons whose performance in the operating room was video-recorded showed that they were generally unaware of being observed because their attention was focused on their performance, teaching, and other aspects of their clinical responsibilities.[7] This was further supported by a study by Rosser et al. reporting that clinicians who were under pressure in an acute ward setting were resistant to the Hawthorne effect.[44] Despite the mixed findings, the Hawthorne effect should be an important consideration when physicians are subjected to observation. For instance, when conducting intra-operative assessment using observation technique, such as the Operating Room Black Box platform,[50-51] investigators must consider possibility of the Hawthorne effect influencing healthcare teams' behaviors and performances.[50,51] To minimize this possibility, observation methods should be indirect and as inconspicuous as possible. Further, a pilot period of several months should be implemented for potential Hawthorne effect to diminish.

There are several potential limitations in our study. First, we did not address potential publication bias. It is possible that studies that did not demonstrate Hawthorne effect were not published. Further, most studies that observed healthcare providers might not have considered measuring and reporting the Hawthorne effect. Secondly, heterogeneity of study designs and methods limited us from performing meta-analysis to generate a quantitative analysis of the Hawthorne effect. Narrative synthesis of evidence – albeit useful – limited objective interpretation of the data. The methodological quality of the selected studies was also heterogeneous. However, only two studies did not pass the criteria and most studies were included in the analysis. Further, all included studies were analyzed by two independent reviewers who reached consensus when disagreement arose.

Despite potential limitations, the present study provides an up-to-date, systematic review of pertinent articles that examined the Hawthorne effect among healthcare professionals. The analysis demonstrated that healthcare professionals were subjected to the Hawthorne effect. In general, they tended to exhibit short-lived positive behavior change when observed, especially with live-person observation. Such behavioral changes induced by the Hawthorne effect should be accounted for when implementing observation tools in both research and clinical settings, as it might have significant implications for the generalizability of results from research and the experiences of patients and healthcare professionals between the research setting and routine practice.

References

1. Roethlisberger FJ, Dickson WJ. Management and the worker: an account of a research program conducted by the Western Electric Company, Hawthorne Works, Chicago, by FJ Roethlisberger and William J. Dickson, with the assistance and collaboration of Harold A. Wright: Harvard Univ. Press; 1964.
2. Morgan L, Robertson E, Hadi M, et al. Capturing intraoperative process deviations using a direct observational approach: The glitch method. BMJ Open. 2013;3 (11) (no pagination)(003519).
3. Levitt SD, List JA. Was there really a Hawthorne effect at the Hawthorne plant? An analysis of the original illumination experiments. American Economic Journal: Applied Economics. 2011;3(1):224-38.
4. Parsons HM. What happened at Hawthorne? Science. 1974;183(4128):922-32.
5. McCambridge J, Witton J, Elbourne DR. Systematic review of the Hawthorne effect: new concepts are needed to study research participation effects. J Clin Epidemiol. 2014;67(3):267-77.
6. James KL, Barlow D, Bithell A, Burfield R, Hiom S, Lord S, et al. Measuring dispensary workload: A comparison of the event recording and direct time techniques. International Journal of Pharmacy Practice. 2011;19(4):264-75.
7. Sutkin G, Littleton EB, Kanter SL. How surgical mentors teach: a classification of in vivo teaching behaviors part 1: verbal teaching guidance. Journal of Surgical Education. 2015;72(2):243-50.
8. Bonafide CP, Lin R, Zander M, et al. Association between exposure to nonactionable physiologic monitor alarms and response time in a children's hospital. J Hosp Med. 2015;10(6):345-51.
9. Chandok N, Speechley M, Ainsworth PJ, et al. The impact of population-based screening studies on hemochromatosis screening practices. Dig Dis Sci. 2012;57(5):1420-2.
10. Verstappen WHJM, Van Der Weijden T, Ter Riet G, et al. Block design allowed for control of the Hawthorne effect in a randomized controlled trial of test ordering. Journal of Clinical Epidemiology. 2004;57(11):1119-23.
11. Wolff CM, Nowacki AS, Yeh J-Y, et al. A randomized controlled trial of two interventions to improve medication reconciliation. Journal of the American Board of Family Medicine. 2014;27(3):347-55 9p.
12. Srigley JA, Furness CD, Baker GR, et al. Quantification of the Hawthorne effect in hand hygiene compliance monitoring using an electronic monitoring system: a retrospective cohort study. BMJ quality & safety. 2014;23(12):974-80.
13. Gould D, Chudleigh J, Drey N, et al. Measuring handwashing performance in health service audits and research studies. Journal of Hospital Infection. 2007;66(2):109-15.
14. Vehmas T. Hawthorne effect: shortening of fluoroscopy times during radiation measurement studies. The British journal of radiology. 1997;70(838):1053-5.
15. Tobe SW, Hunter K, Geerts R, et al. Canadian Hypertension S. IMPPACT: Investigation of Medical Professionals and Patients Achieving Control Together. Can J Cardiol. 2008;24(3):205-8.
16. Holden JD. Hawthorne effects and research into professional practice. J Eval Clin Pract. 2001;7(1):65-70.
17. Zucker TP, Flesche CW, Germing U, et al. Patient-controlled versus staff-controlled analgesia with pethidine after allogeneic bone marrow transplantation. Pain. 1998;75(2-3):305-12.
18. Sedgwick P, Greenwood N. Understanding the hawthorne effect. BMJ (Online). 2015;351 (no pagination)(h4672).
19. McCarney R, Warner J, Iliffe S, et al. The Hawthorne Effect: a randomised, controlled trial. BMC Medical Research Methodology. 2007;7:30.
20. Van den Hombergh P, Grol R, Van Den Hoogen H, et al. Practice visits as a tool in quality improvement: mutual visits and feedback by peers compared with visits and feedback by non-physician observers. Quality and Safety in Health Care. 1999;8(3):161-6.
21. Mangione-Smith R, Elliott MN, McDonald L, et al. An observational study of antibiotic prescribing behavior and the Hawthorne effect. Health Serv Res. 2002;37(6):1603-23.
22. Leonard K, Masatu MC. Outpatient process quality evaluation and the Hawthorne Effect. Social Science & Medicine. 2006;63(9):2330-40.

23. Campbell JP. Hawthorne effect: implications for prehospital research. Annals of Emergency Medicine. 1995;26(5):590-4 5p.
24. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS medicine. 2009;6(7):e1000097.
25. National Heart L, Institute B. Quality assessment tool for observational cohort and cross-sectional studies. Bethesda, MD: National Institutes of Health, Department of Health and Human Services. 2014.
26. Bittner MJ, Rich EC, Turner PD, et al. Limited impact of sustained simple feedback based on soap and paper towel consumption on the frequency of hand washing in an adult intensive care unit. Infect Control Hosp Epidemiol. 2002;23(3):120-6.
27. Campino A, Lopez-Herrera MC, Lopez-de-Heredia I, et al. Medication errors in a neonatal intensive care unit. Influence of observation on the error rate. Acta Paediatr. 2008;97(11):1591-4.
28. Collar RM, Shuman AG, Feiner S, et al. Lean management in academic surgery. Journal of the American College of Surgeons. 2012;214(6):928-36.
29. Eckmanns T, Bessert J, Behnke M, et al. Compliance with antiseptic hand rub use in intensive care units: the Hawthorne effect. Infect Control Hosp Epidemiol. 2006;27(9):931-4.
30. Edwards KE, Hagen SM, Hannam J, et al. A randomized comparison between records made with an anesthesia information management system and by hand, and evaluation of the Hawthorne effect. Canadian Journal of Anesthesia. 2013;60(10):990-7.
31. Evans CL, Kim YM, Yari K, et al. Using direct clinical observation to assess the quality of cesarean delivery in Afghanistan: an exploratory study. BMC Pregnancy & Childbirth. 2014;14:176.
32. Fernald DH, Coombs L, DeAlleaume L, et al. An assessment of the Hawthorne effect in practice-based research. Journal of the American Board of Family Medicine. 2012;25(1):83-6.
33. Fox NS, Brennan JS, Chasen ST. Clinical estimation of fetal weight and the Hawthorne effect. European Journal of Obstetrics, Gynecology, & Reproductive Biology. 2008;141(2):111-4.
34. Gruber T, Sharma A, Daneschvar H, Estfan B. Pain and symptom management. The Hawthorne effect in the assessment of pain by house staff. American Journal of Hospice & Palliative Care. 2003;20(3):231-4 4p.
35. Hagel S, Reischke J, Kesselmeier M, et al. Quantifying the Hawthorne Effect in Hand Hygiene Compliance Through Comparing Direct Observation With Automated Hand Hygiene Monitoring. Infection Control & Hospital Epidemiology. 2015;36(8):957-62.
36. Harbarth S, Pittet D, Grady L, et al. Interventional study to evaluate the impact of an alcohol-based hand gel in improving hand hygiene compliance. Pediatr Infect Dis J. 2002;21(6):489-95.
37. Kohli E, Ptak J, Smith R, et al. e effect with regard to hand hygiene performance in high- and low-performing inpatient care units. Infection Control & Hospital Epidemiology. 2009;30(3):222-5.
38. Lam HT, Schweitzer SO, Petz L, et al. Effectiveness of a prospective physician self-audit transfusion-monitoring system. Transfusion. 1997;37(6):577-84.
39. Leurent B, Reyburn H, Muro F, et al.. Monitoring patient care through health facility exit interviews: an assessment of the Hawthorne effect in a trial of adherence to malaria treatment guidelines in Tanzania. BMC Infectious Diseases. 2016;16:59.
40. Miller DG, Walz D. The hawthorne effect, metrics and emergency physicians' head CT practice. Annals of Emergency Medicine. 2014;1):S66.
41. Pan SC, Tien KL, Hung IC, et al. Compliance of health care workers with hand hygiene practices: independent advantages of overt and covert observers. PLoS One. 2013;8(1):e53746.
42. Pittet D, Simon A, Hugonnet S, et al. Hand hygiene among physicians: performance, beliefs, and perceptions. Ann Intern Med. 2004;141(1):1-8.
43. Rheineck-Leyssius AT, Kalkman CJ, Trouwborst A. Influence of motivation of care providers on the incidence of postoperative hypoxaemia in the recovery room. British Journal of Anaesthesia. 1996;77(4):453-7.
44. Rosser RM. The reliability and application of clinical judgment in evaluating the use of hospital beds. Med Care. 1976;14(1):39-47.
45. Yin J, Reisinger HS, Vander Weg M, et al. Establishing evidence-based criteria for directly observed hand hygiene compliance monitoring programs: a prospective, multicenter cohort study. Infect Control Hosp Epidemiol. 2014;35(9):1163-8.
46. Dhar S, Tansek R, Toftey EA, et al. Observer bias in hand hygiene compliance reporting. Infection Control & Hospital Epidemiology. 2010;31(8):869-70.
47. Maury E, Moussa N, Lakermi C, et al. Compliance of health care workers to hand hygiene: Awareness of being observed is important [8]. Intensive Care Medicine. 2006;32(12):2088-9.
48. Miller NP, Amouzou A, Hazel E, et al. Assessing the Quality of Sick Child Care Provided by Community Health Workers. PLoS ONE [Electronic Resource]. 2015;10(11):e0142010.
49. Jones SRG. Was There a Hawthorne Effect? American Journal of Sociology. 1992;98(3):451-68.
50. Goldenberg MG, Jung J, Grantcharov TP. Using data to enhance performance and improve quality and safety in surgery. JAMA Surgery. 2017.
51. Langerman A, Grantcharov TP. Are We Ready for Our Close-up?: Why and How We Must Embrace Video in the OR. Annals of Surgery. 2017.

Appendix 1. Detailed Search Protocol

Database: Ovid MEDLINE(R) Daily Update <June 17, 2016>, Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) <1946 to Present>, Ovid MEDLINE(R) Epub Ahead of Print <June 17, 2016>

Search Strategy:

1 exp Health Personnel/ (422268)
2 (health adj2 (provider* or personnel or professional* or worker* or practitioner* or staff)).tw. (123699)
3 (healthcare adj3 (provider* or personnel or professional* or worker* or practitioner* or staff)).tw. (33682)
4 (medical adj1 (provider* or personnel or professional* or worker* or practitioner* or staff)).tw. (27358)
5 (surgical adj1 (provider* or personnel or professional* or worker* or practitioner* or staff)).tw. (739)
6 emergency medical technician*.tw. (844)
7 emergency medicine technician*.tw. (13)
8 paramedic*.tw. (6292)
9 nurs*.tw. (373047)
10 physician*.tw. (315955)
11 surgeon*.tw. (151463)
12 physiotherapist*.tw. (5453)
13 therapist*.tw. (29833)
14 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 (1207331)
15 Effect Modifier, Epidemiologic/ (1160)
16 Hawthorne effect*.tw. (221)
17 observer effect*.tw. (106)
18 (aware* adj3 observ*).tw. (370)
19 15 or 16 or 17 or 18 (1801)
20 14 and 19 (234)

Database: EBM Reviews - Cochrane Central Register of Controlled Trials <May 2016>

Search Strategy:

1 exp Health Personnel/ (5671)
2 (health adj2 (provider* or personnel or professional* or worker* or practitioner* or staff)).ti,ab,hw. (7988)
3 (healthcare adj3 (provider* or personnel or professional* or worker* or practitioner* or staff)).ti,ab,hw. (1203)
4 (medical adj1 (provider* or personnel or professional* or worker* or practitioner* or staff)).ti,ab,hw. (1125)
5 (surgical adj1 (provider* or personnel or professional* or worker* or practitioner* or staff)).ti,ab,hw. (30)
6 emergency medical technician*.ti,ab,hw. (175)
7 emergency medicine technician*.ti,ab,hw. (0)
8 paramedic*.ti,ab,hw. (504)
9 nurs*.ti,ab,hw. (17039)
10 physiotherapist*.ti,ab,hw. (1529)
11 physician*.ti,ab,hw. (18245)
12 surgeon*.ti,ab,hw. (7276)
13 therapist*.ti,ab,hw. (3553)
14 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 (51907)

15 Effect Modifier, Epidemiologic/ (89)
16 Hawthorne effect*.ti,ab,hw. (80)
17 observer effect*.ti,ab,hw. (8)
18 (aware* adj3 observ*).ti,ab,hw. (56)
19 15 or 16 or 17 or 18 (218)
20 14 and 19 (46)

Database: Embase Classic+Embase <1947 to 2016 Week 25>

Search Strategy:

1 exp health care personnel/ (1179786)
2 (Health adj2 (provider* or personnel or professional* or worker* or practitioner* or staff)).tw. (149642)
3 (Healthcare adj3 (provider* or personnel or professional* or worker* or practitioner* or staff)).tw. (44746)
4 (Medical adj1 (provider* or personnel or professional* or worker* or practitioner* or staff)).tw. (37670)
5 (Surgical adj1 (provider* or personnel or professional* or worker* or practitioner* or staff)).tw. (966)
6 Emergency medical technician*.tw. (1037)
7 Emergency medicine technician*.tw. (18)
8 paramedic*.tw. (9135)
9 nurs*.tw. (428763)
10 physician*.tw. (438789)
11 surgeon*.tw. (242408)
12 physiotherapist*.tw. (11027)
13 therapist*.tw. (48200)
14 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 (1942009)
15 hawthorne effect/ (341)
16 Hawthorne effect*.tw. (343)
17 observer effect*.tw. (117)
18 (aware* adj3 observ*).tw. (505)
19 15 or 16 or 17 or 18 (1124)
20 14 and 19 (306)
21 limit 20 to embase (272)

Database: PsycINFO Search Strategy

Search History (22) View Saved

# ▲	Searches	Results	Type	Actions	Annotations
1	exp Health Personnel/	2138	Advanced	Display Results | More	
2	exp COUNSELORS/	558	Advanced	Display Results | More	
3	Rescue Workers/	3	Advanced	Display Results | More	
4	exp THERAPISTS/	652	Advanced	Display Results | More	
5	(Health adj2 (provider* or personnel or professional* or worker* or practitioner* or staff)).tw.	195	Advanced	Display Results | More	
6	(Healthcare adj3 (provider* or personnel or professional* or worker* or practitioner* or staff)).tw.	0	Advanced	Remove | More	
7	(Medical adj1 (provider* or personnel or professional* or worker* or practitioner* or staff)).tw.	193	Advanced	Display Results | More	
8	(Surgical adj1 (provider* or personnel or professional* or worker* or practitioner* or staff)).tw.	1	Advanced	Display Results | More	
9	Emergency medical technician*.tw.	0	Advanced	Remove | More	
10	Emergency medicine technician*.tw.	0	Advanced	Remove | More	
11	paramedic*.tw.	10	Advanced	Display Results | More	
12	nurs*.tw.	3047	Advanced	Display Results | More	
13	physician*.tw.	3286	Advanced	Display Results | More	
14	surgeon*.tw.	281	Advanced	Display Results | More	
15	physiotherapist*.tw.	13	Advanced	Display Results | More	
16	therapist*.tw.	3137	Advanced	Display Results | More	
17	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16	11518	Advanced	Display Results | More	
18	Hawthorne effect*.tw.	5	Advanced	Display Results | More	
19	observer effect*.tw.	2	Advanced	Display Results | More	
20	(aware* adj3 observ*).tw.	14	Advanced	Display Results | More	
21	18 or 19 or 20	21	Advanced	Display Results | More	
22	17 and 21	0	Advanced	Remove | More	

Contract

Appendix 2. Quality assessment tool for observational cohort and cross-Sectional Studies

Authors	Quality[a]	Authors	Quality[a]
Bittner, et al.	Fair	Kohli, et al.	Good
Campbell, et al.	Fair	Lam, et al.	Fair
Campino, et al.	Fair	Leonard, et al.	Good
Collar, et al.	Fair	Leurent, et al.	NA[c]
Dhar, et al.	Poor[b]	Mangione-Smith, et al.	Fair
Eckmanns, et al.	Fair	Maury, et al.	Poor[d]
Edwards, et al.	Good	Miller, et al.	Fair
Evans, et al.	Fair	Pan, et al.	Fair
Fernald, et al.	Fair	Pittet, et al.	Fair
Fox, et al.	Fair	Rheineck-Leyssius, et al.	Fair
Gruber, et al.	Fair	Rosser, et al.	Fair
Hagel, et al.	Fair	Yin, et al.	Fair
Harbarth, et al.	Good		

[a]Authors WC and JJ independently rated the scores but decided together on the final study quality ratings.

[b]This study was rated as "poor" as the sample of interest was poorly defined, no exposure and outcome description were reported, study was non-blinded, and confounding variables were not adjusted

[c]Randonmized control studies are not eligible for this assessment

[d]This study was rated as "poor" as the study population was not clearly defined, subjects were heterogeneous, study time frame was not sufficient, confounding variables were not adjusted but a correspondence

Abbreviations: CD, cannot determine; NA, not applicable; NR, not reported.

Criteria: 1. Was the research question or objective in this paper clearly stated? 2. Was the study population clearly specified and defined? 3. Was the participation rate of eligible persons at least 50%? 4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants? 5. Was a sample size justification, power description, or variance and effect estimates provided? 6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured? 7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed? 8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)? 9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? 10. Was the exposure(s) assessed more than once over time? 11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? 12. Were the outcome assessors blinded to the exposure status of participants? 13. Was loss to follow-up after baseline 20% or less? 14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?