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A systematic scoping review of environmental health conditions and hygiene behaviors in homeless shelters

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ABSTRACT

Background: There are well-established relationships between health and homelessness, and shelters can facilitate the transmission of diseases and contribute to their prevention. Adequate environmental health conditions and hygiene behaviors in homeless shelters are fundamental to the health of their clients, a marginalized population. We report the status of environmental health conditions and hygiene behaviors in homeless shelters and associated health outcomes; interventions to improve these conditions, behaviors, and outcomes; and obstacles to improvement.

Methods: PubMed, Web of Science, Scopus, and EBSCOhost were searched for peer-reviewed studies, and additional sources for grey literature. Studies were included if they reported primary data on one or more environmental health condition or hygiene behavior in homeless shelters.

Results: Twenty-eight studies were included in the review. Insufficient ventilation systems, unhygienic bedding, and overcrowding were the most documented environmental health and hygiene deficiencies in homeless shelters, and tuberculosis infections and skin diseases were the most documented associated health outcomes among clients. Studies frequently recommended or described implementation of behavioral and administrative controls, ventilation system improvements, and ultraviolet germicidal irradiation fixtures.

Discussion: Most studies addressed airborne transmission of tuberculosis and were conducted in high-income countries, revealing an imbalance in the literature. Insufficient resources and the transience of clients are barriers to improving hygiene behaviors and environmental conditions in homeless shelters. Further investment and research into ensuring adequate hygiene and environmental health in this setting can protect and promote the health and well-being of people experiencing homelessness.

1. Introduction

The United Nations Special Rapporteur on the human right to adequate housing called homelessness the “most severe symptom of the lack of respect for the right to adequate housing” (UN Office of the High Commissioner for Human Rights, 2014). As a source of temporary and crisis housing, homeless shelters play a pivotal role in meeting the basic needs of people experiencing homelessness on a short-term basis. Adequate environmental health conditions, opportunities to practice good hygiene, and the implementation of control measures to prevent disease transmission are necessary in shelters to protect and promote the health of this marginalized population.

Homelessness is manifested, defined, and managed differently across cultures and world regions. For measurement purposes, the United Nations (U.N.) defines homelessness as “persons living in streets or without shelter that would fall within the scope of living quarters; persons with no place of usual residence who move frequently between various types of accommodation (including dwellings, shelters or other living quarters); persons who usually reside in long-term (also called “transitional”) shelters or similar arrangements for the homeless” (United Nations Department of Economic and Social Affairs Statistics Division, 2017). Under this definition, the U.N. estimates 100 million people worldwide are homeless (Kothari, 2005). The United States of America (U.S.A.) Department of Housing and Urban Development estimates over 550,000 people experience homelessness each night in the U.S.A., one-third of whom are in families and two-thirds of whom are in

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sheltered locations such as emergency shelters, transitional housing, and safe havens (Henry et al., 2017). Homelessness may be more extensive than estimated, as surveys or shelter counts can miss intermittent or short-term homelessness and those who deny they are experiencing homelessness (Link et al., 1994).

Homelessness is associated with poverty, affordable housing shortages, unemployment, substance abuse, and domestic violence, as well as mental illness, particularly in the wake of deinstitutionalization efforts (Belcher and Toomey, 1988; Fazel et al., 2014; UN Office of the High Commissioner for Human Rights, 2014). Gender and sexual minorities, racial minorities, and people with a history of imprisonment are overrepresented in the homeless population (Cochran et al., 2002; Jones, 2016; Metraux and Culhane, 2004).

The cyclical relationships between health and homelessness is well-documented, where some health problems contribute to or are a consequence of homelessness (Committee on Health Care for Homeless People, 1988). There is a greater prevalence of infectious disease among people experiencing homelessness. Human immunodeficiency virus (HIV), hepatitis C, and tuberculosis are most documented, in addition to skin problems such as scabies, pediculosis (lice), and the louse-transmitted *Bartonella quintana* (Beijer et al., 2012; Fazel et al., 2014; Raoult et al., 2001). Healthcare is complicated for people experiencing homelessness who are often unable to access treatment or transportation to treatment (Committee on Health Care for Homeless People, 1988; Raoult et al., 2001). The prevalence of infectious diseases such as HIV and high-risk behaviors such as substance abuse among people experiencing homelessness presents an imperative for preventing and controlling infectious diseases among this vulnerable population.

Homeless shelters can facilitate the transmission of infectious diseases and contribute to their prevention and control among their clients (Badiaga et al., 2008b; Raoult et al., 2001). Adequate environmental health conditions and hygiene behaviors – including water supply, sanitation, ventilation, waste management, vector management, handwashing, food-handling, and cleaning shared items – in homeless shelters can protect the health of clients.

Previous systematic reviews have sought to characterize health outcomes and healthcare interventions among the homeless, but the literature on environmental health conditions and hygiene behaviors in homeless shelters has not been comprehensively reviewed. Following the launch of the Sustainable Development Goals (SDGs) in 2015, there was increased attention to environmental health in non-household settings, including involuntarily displaced person settings such as homeless shelters, through goals such as SDG 6, which calls for universal access to basic water, sanitation, and hygiene services (Behnke et al., 2018; Cronk et al., 2015; United Nations General Assembly, 2015). There is little data to characterize the patterns, levels, and trends in environmental health services in these settings (Chatterley et al., 2018).

We conducted a systematic scoping review of the literature on environmental health conditions and hygiene behaviors in homeless shelters to explore:

- What evidence is available about hygiene behaviors and environmental health conditions in homeless shelters, and what are the documented associated health outcomes?
- What are the obstacles preventing improvements in hygiene behaviors and environmental health conditions in homeless shelters described in this literature?
- What interventions have been reportedly successful in improving hygiene, environmental health, and associated outcomes in homeless shelters?
- What are the gaps in evidence regarding hygiene behaviors and environmental health conditions in homeless shelters?

2. Methods

We conducted our review according to the guidance of Peters et al. (2015) (Peters et al., 2015). The review specifically concerned shelters and not the homeless population and their interactions with other environments and settings.

2.1. Definitions

A homeless shelter was defined as a staffed institution that provides overnight shelter on a temporary (non-permanent) basis for people without homes or people seeking asylum from their homes due to abuse or domestic violence. Institutions providing meals, healthcare, or other services to the homeless without overnight accommodation were excluded. Environmental health conditions and hygiene behaviors were defined to encompass water, sanitation, ventilation, air quality, waste management, vectors, overcrowding, fomites or shared items, personal hygiene, handwashing, and food hygiene.

2.2. Eligibility

Studies were included if they reported primary data on one or more environmental health conditions or hygiene behaviors in a homeless shelter. Press releases, news articles, and non-English publications were excluded. There was no limit on the date of publication.

2.3. Search strategy

Search queries comprised a string of environmental health and hygiene terms and a string of settings terms (see supplementary materials). Settings terms included both homeless shelters and institutional care settings for orphaned and abandoned children; only homeless shelter studies are reviewed in this study.

Peer-reviewed studies were identified using PubMed, Web of Science, Scopus, and EBSCOhost. The peer-reviewed literature search was conducted on September 23, 2017. Three independent reviewers screened titles and abstracts using Cochrane's Covidence software. Abstracts approved by two reviewers were included in full-text screening. A fourth reviewer resolved conflicts. Full texts approved by two reviewers were included in the review.

The following websites were searched to identify grey literature: United States Centers for Disease Control and Prevention (U.S. CDC); United Nations Children's Fund (UNICEF); World Health Organization (WHO); World Bank; RAND Corporation; UN-Documentation Centre on Water and Sanitation; IRC WASH Library; and non-profit or non-governmental organization websites identified through Google searches. The grey literature search was updated in January 2018.

Additional studies were identified by screening references of included studies.

2.4. Data extraction and synthesis

The following data were extracted from included studies: shelter characteristics (location, managing authority, and capacity); documented environmental health conditions and hygiene behaviors; health outcomes and population affected (number affected, risk factors that would predispose clients to adverse health outcomes such as substance abuse or chronic disease, and if staff were affected); implemented or recommended interventions (infrastructural, behavioral, or administrative); obstacles and challenges to improving conditions; and study limitations. We noted when studies claimed statistical significance for their findings. Extracted data were tabulated to compare and summarize findings. R software version 3.1.5 and RStudio 1.1.456 were used to map relationships and findings using the “threejs” package. Due to heterogeneity of collected data, meta-analysis was not performed.

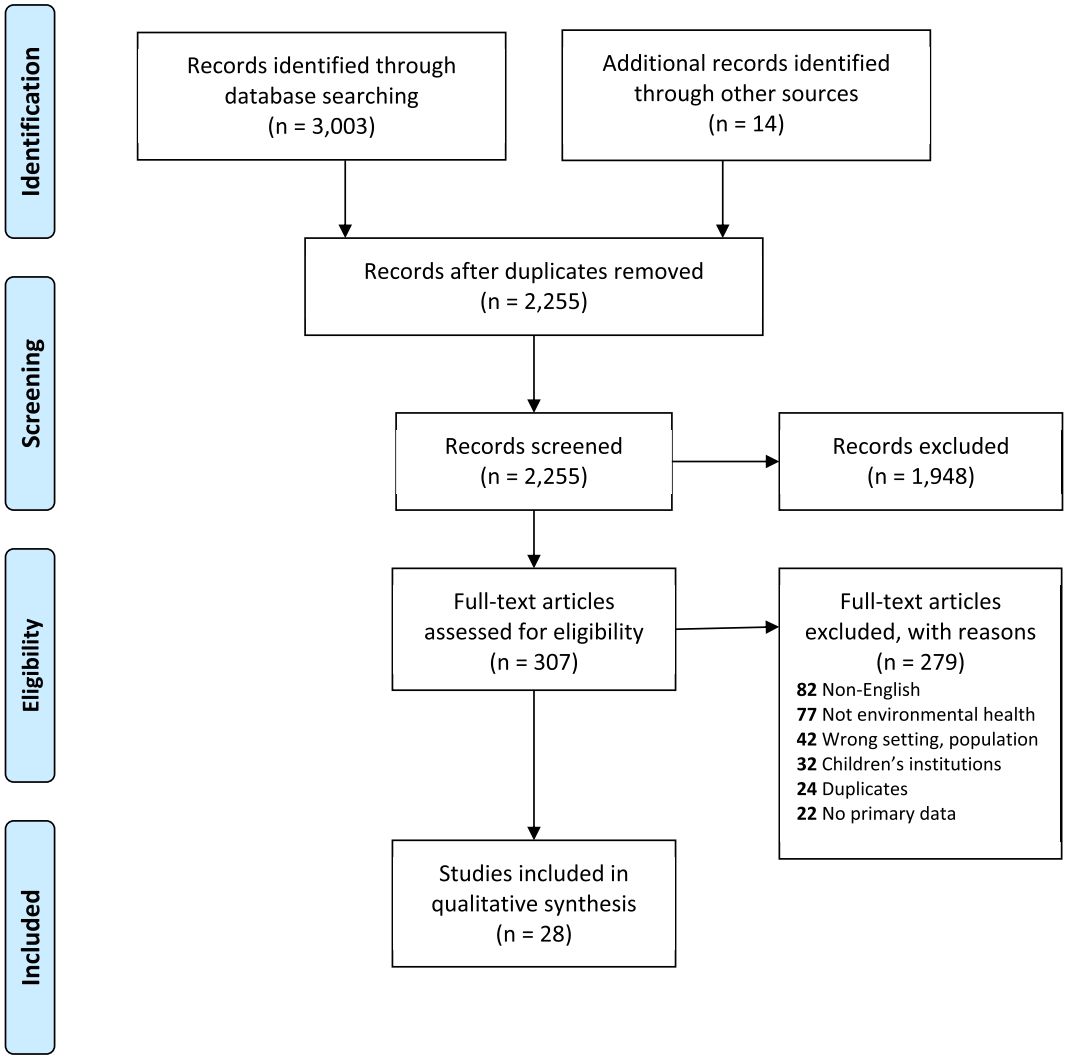

Fig. 1. Schematic of search strategy for a systematic scoping review on environmental health conditions and hygiene behaviors in homeless shelters.

3. Results

3.1. Search results and study characteristics

Twenty-eight studies satisfied the inclusion criteria, as shown in Fig. 1. Table 1 lists the metadata for included studies and Table 2 summarizes extracted data.

Included studies were published between 1987 and 2017, with study lengths ranging from a single day to seven years. The majority of studies took place in the U.S.A. (n = 20, 75%), followed by France (n = 5, 18%) and Canada (n = 2, 7%); one study took place in India. Common study designs included cross-sectional studies on shelter clients (n = 7, 25%), case studies on a shelter's environmental controls (n = 7, 25%), and surveys of shelter clients or directors (n = 5, 18%).

The studies included over 180 distinct homeless shelters. Four studies included the same two shelters in Marseilles, France (Badiaga et al., 2008a, 2005; Brouqui et al., 2005; Keita et al., 2013); three others studied a single shelter in St. Louis, Missouri, U.S.A.(Coffey et al., 2009; Martin, Jr. and Coffey, 2005; Misselbeck and Phillips, 2005). Ten studies (36%) included shelters managed by non-governmental organizations including faith-based organizations (Coffey et al., 2009; Martin, Jr. and Coffey, 2005; Martin et al., 2014a, 2014b; 2013a, 2013b; 2013c; Misselbeck and Phillips, 2005; Stratigos et al., 1999; Torres et al., 1990); four studies (14%) concerned state-run shelters (Goel et al., 2017; Gross and Rosenberg, 1987; Hudson et al., 2005; Nolan et al., 1991); the remaining studies did not specify the managing authority. Half of the studies from the U.S.A. or Canada had one or more authors associated with the respective country's Centers for Disease Control and Prevention (CDC) (Coffey et al., 2009; Curtis et al., 2000; Gross and Rosenberg, 1987; Hudson et al., 2005; Martin, Jr. and Coffey, 2005; Martin et al., 2014a, 2014b, 2013a, 2013b, 2013c).

Homeless shelters in included studies had 74-1001 beds. Ten studies (36%) included shelters for adult men only, and one study included only shelters for battered women and their children (Gross and Rosenberg, 1987). The remaining studies included shelters accommodating a broader population or did not specify a particular population. All shelters accommodated short-term clients; several also included long-term clients, such as those too injured or sick to work, those in a rehabilitation program, or military veterans. The shelters in the study in India often housed people who were not homeless by the definition cited in this paper, such as tourists who could not afford a hotel (Goel et al., 2017).

3.2. Environmental health conditions and hygiene behaviors

Thirteen studies (46%) observed inadequate ventilation, insufficient outdoor air supply, and/or the poor state of air-handling units in studied shelters. Five studies (18%) noted overcrowded conditions. One study found a subset of shelters isolate clients with diarrhea, while others (n = 4, 14%) noted an absence of procedures to isolate

Table 1
Studies included in synthesis of hygiene behaviors and environmental health conditions in homeless shelters.

Author	Title	Country	Study design	Number of shelters
Badiaga et al. (2005)	Prevalence of skin infections in sheltered homeless	France	Cross-sectional	2
Badiaga et al. (2008a,b)	The effect of a single dose of oral ivermectin on pruritus in the homeless	France	Randomized control trial	2
Brouqui et al. (2005)	Ectoparasitism and vector-borne diseases in 930 homeless people from Marseilles	France	Cohort	2
Buu et al. (2014)	Asthma, tobacco smoke and the indoor environment: A qualitative study of sheltered homeless families	USA	Survey	1
Coffey et al. (2009)	Improving the environmental controls at a homeless shelter to assist in reducing the probability of airborne transmission of *Mycobacterium tuberculosis*: A case study	USA	Case study	1
Crisan et al. (2015)	Spatio-temporal analysis of tuberculosis infection risk among clients of a homeless shelter during an outbreak	Canada	Cohort	1
Curtis et al. (2000)	Analysis of *Mycobacterium tuberculosis* transmission patterns in a homeless shelter outbreak	USA	Case series	1
Goel et al. (2017)	Urban homeless shelters in India: Miseries untold and promises unmet	India	Survey	4
Gross and Rosenberg (1987)	Shelters for battered women and their children: An under-recognized source of communicable disease transmission	USA	Survey	73
Ho et al. (2007)	Health and housing among low-income adults with physical disabilities	USA	Survey	1
Hudson et al. (2005)	Tuberculosis transmission in a homeless shelter population – New York, 2000–2003	USA	Cross-sectional	1
Hwang et al. (2005)	Bed bug infestations in an urban environment	Canada	Survey	65
Keita et al. (2013)	Tropheryma whipplei prevalence strongly suggests human transmission in homeless shelters	France	Cross-sectional	2
Lefeuvre et al. (2016)	Asthma-like symptoms in homeless children in the greater Paris area in 2013: Prevalence, associated factors and utilization of healthcare services in the ENFAMS survey	France	Cross-sectional	Not specified
Martin and Coffey (2005)	NIOSH health hazard evaluation report: Salvation Army Harbor Light Centre	USA	Case study	1
Martin et al. (2013a)	Evaluation of environmental controls at a homeless shelter (City Rescue Mission–New Life Inn) associated with a tuberculosis outbreak – Florida	USA	Case study	1
Martin et al. (2013b)	Evaluation of environmental controls at a homeless shelter complex (City Rescue Mission–McDuff Campus) associated with a tuberculosis outbreak – Florida	USA	Case study	1
Martin et al. (2013c)	Evaluation of environmental controls at a homeless shelter (Trinity Rescue Mission) associated with a tuberculosis outbreak – Florida	USA	Case study	1
Martin et al. (2014a)	Evaluation of environmental controls at a faith-based homeless shelter associated with a tuberculosis outbreak – Texas	USA	Case study	1
Martin et al. (2014b)	Evaluation of environmental controls at a homeless shelter associated with a tuberculosis outbreak – Texas	USA	Case study	1
Mayo et al. (1996)	Community collaboration: Prevention and control of tuberculosis in a homeless shelter	USA	Case series	1
McElroy et al. (2003)	Outbreak of tuberculosis among homeless persons coinfected with human immunodeficiency virus	USA	Case series	1
Misselbeck and Phillips (2005)	New and old ideas blend well at Harbor Light Shelter	USA	Case series	1
Nardell et al. (2008)	Safety of upper-room ultraviolet germicidal air disinfection for room occupants: Results from the tuberculosis ultraviolet shelter study	USA	Randomized control trial	14
Nolan et al. (1991)	An outbreak of tuberculosis in a shelter for homeless men: A description of its evolution and control	USA	Case-control	1
Ottomeyer et al. (2016)	Prevalence of nasal colonization by methicillin-resistant *Staphylococcus aureus* in persons using a homeless shelter in Kansas City	USA	Cross-sectional	1
Stratigos et al. (1999)	Prevalence of skin disease in a cohort of shelter-based homeless men	USA	Cross-sectional	1
Torres et al. (1990)	Human immunodeficiency virus infection among homeless men in a New York City shelter	USA	Cross-sectional	1

Table 2
Summary of extracted data. Reported pathogens and health outcomes noted with number of clients affected and proportion of total clients included in study, as available.

Study	Hygiene behaviors and environmental health conditions	Reported pathogens and health outcomes	Implemented hygiene and environmental health interventions	Recommended hygiene and environmental health interventions
Badiaga et al. (2005)	Showers available, clothes available; laundry available; poor foot hygiene; overcrowded	Pruritus (181, 36%); body lice (103, 21%); fleas (2, 0.4%); scabies (19, 4%); impetigo (12, 2%); folliculitis (24, 5%); tinea pedis (16, 3%); erysipelas (7, 1%); onychomycosis (26, 5%); phthirus pubis (4, 1%); scratching lesions	–	Improve footcare
Badiaga et al. (2008a,b)	Showers available; clothes available; laundry available; overcrowded	Scabies, body lice (76, 93%)	–	Change clothes more frequently
Brouqui et al. (2005)	Showers available; clothes available; laundry available; bedding found with lice	Scratching lesions indicative of body lice (205, 22%); scabies (27, 3%); louse-borne relapsing fever (15, 2%); epidemic typhus (7, 1%); microorganism in blood cultures (58, 6%), including *Bartonella quintana*, *Acinetobacter* sp., *Streptococcus* sp., *Staphylococcus* sp.	–	Boil or treat blankets with insecticide; yearly base survey of scabies and louse-borne disease
Buu et al. (2014)	Asthma triggers, including carpets, mattresses, upholstery; ventilation; second-hand smoke	Asthma	–	Improve ventilation to prevent mold and mildew growth; hypoallergenic mattresses or mattress covers; hypoallergenic floors, remove carpet; indoor and outdoor clean air, tobacco smoking bans; train and educate shelter staff on asthma
Coffey et al. (2009)	Showers available; ventilation, outside air supply inadequate	*Mycobacterium tuberculosis*, active (19)	Installed upper-room UVGI; increased outside air supply by opening doors and windows	UVGI in air handling units; further increase outdoor air supply; upgrade air filters; improve AHU testing and maintenance
Crisan et al. (2015)	Showers available; laundry available; ventilation equipped with air-purifiers	*Mycobacterium tuberculosis*, active (8, 14%); *Mycobacterium tuberculosis*, latent, converted TST (31, 53%)	–	Improve minimum air changes; UVGI; improve ventilation of areas other than sleeping quarters
Curtis et al. (2000)	Overcrowding; ventilation, airflow inadequate	*Mycobacterium tuberculosis*, active (10); *Mycobacterium tuberculosis*, latent, converted TST (19, 11%); *Mycobacterium tuberculosis*, latent, no baseline TST (37, 21%)	Installed new HVAC system, portable high-efficiency particulate air filters; sends new clients to local health department for tuberculosis screening	Promptly screen contacts of infectious persons
Goel et al. (2017)	Drinking water often available, sometimes low quality or shortage; sanitation inadequate or costly; laundry lacking or inadequate; bedding inadequate or dirty; ventilation, cooling lacking or inadequate; fire safety lacking; pest control lacking	–	–	Fire-resistant materials, fire alarms; improve water and sanitation services; decrease sanitation usage charges; improve supervision of maintenance of shelters
Gross and Rosenberg (1987)	Handwashing inadequate; food-handling hygiene inadequate; some shelters isolated clients with diarrhea; lacking designated areas for diapering infants, disposing of diapers; soap available	Diarrheal illness; lice; scabies; upper respiratory infections; chickenpox; measles; pertussis; conjunctivitis; impetigo; hepatitis	–	Improve handwashing; paper towel dispensers; designate diaper-changing areas; cohort sick persons; screen for illness and improve protocols for handling infectious disease
Ho et al. (2007)	Water rationing; bathrooms and showers not wheelchair accessible, often broken; overcrowding	Pressure sores	–	–
Hudson et al. (2005)	Ventilation, outdoor air supply inadequate	*Mycobacterium tuberculosis*, active (29); *Mycobacterium tuberculosis*, latent (436, 46%)	–	Strengthen interjurisdictional tuberculosis reporting procedures
Hwang et al. (2005)	Showers available; laundry available; bed bugs found on beds, mattresses, bedding, floors, walls, lockers, personal belongings, furniture	Bed bug bites	Removed floorboards, baseboards, wood trim; replaced carpets; sealed floor cracks, painted wooden floors; installed additional washers and dryers	Launder bed linens daily; steam clean and vacuum mattresses; vacuum rooms
Keita et al. (2013)	Hygiene inadequate	*Tropheryma whipplei*, in stool (21, 13%); *Tropheryma whipplei*, in saliva (8, 4%)	–	–
Lefeuvre et al. (2016)	Poor bedding; dampness; overcrowding; second-hand smoke	Asthma-like symptoms, defined as wheezing or night cough without fever (20%)	–	Limit asthma triggers including dampness

(*continued on next page*)

Table 2 (*continued*)

Study	Hygiene behaviors and environmental health conditions	Reported pathogens and health outcomes	Implemented hygiene and environmental health interventions	Recommended hygiene and environmental health interventions
Martin and Coffey (2005)	Showers available; ventilation, outside air supply inadequate	*Mycobacterium tuberculosis*, active (19)	Cleaned outside of AHUs; replaced fan belts, repaired sensors and controllers, repaired outside air dampers; installed UVGI fixtures, silent air mover unit, upper-room UV units; improved maintenance procedures for ventilation systems; upgraded air filters	Train shelter staff and contractors on operation and maintenance of ventilation and UV units; upgrade ventilation system; evaluate HVAC system; additional UVGI fixtures
Martin et al. (2013a)	Showers available; no isolation of infected clients; ventilation, outside air supply inadequate	*Mycobacterium tuberculosis*	Trained employees and volunteers on tuberculosis symptoms and prevention; screens new clients for tuberculosis	Develop written infection control plan, including tuberculosis and hygiene education; increase outdoor air supply and air flow; fix condensate leaks from AHUs; upgrade air filters; create respiratory separation area for infected clients; develop respiratory protection program; repair or replace bathroom exhaust fans; install safety features on UV systems; develop HVAC operation and maintenance plan
Martin et al. (2013b)	No isolation of infected clients; ventilation, outside air supply inadequate	*Mycobacterium tuberculosis*	Trained employees and volunteers on tuberculosis symptoms and prevention; screens new clients for tuberculosis	Develop written infection control plan, including tuberculosis and hygiene education; increase outdoor air supply and air flow; fix standing water inside AHU; upgrade air filters; create respiratory separation area for infected clients; develop respiratory protection program; repair or replace bathroom exhaust fans; develop HVAC operation and maintenance plan
Martin et al. (2013c)	Showers available; laundry available; no isolation of infected clients; ventilation, outside air supply inadequate	*Mycobacterium tuberculosis*	–	Train employees and volunteers on tuberculosis symptoms and prevention; screen new clients for tuberculosis; develop written infection control plan, including tuberculosis and hygiene education; increase outdoor air supply and air flow; upgrade air filters; create respiratory separation area for infected clients; upper-room UVGI system; develop respiratory protection program; repair or replace bathroom exhaust fans; develop HVAC operation and maintenance plan
Martin et al. (2014a)	Showers available; ventilation adequate; outside air supply inadequate	*Mycobacterium tuberculosis*	Trained employees and volunteers on tuberculosis symptoms and prevention; screens new clients for tuberculosis	Develop written infection control plan, including tuberculosis and hygiene education; create respiratory separation area for infected clients; repair or replace AHUs as needed; repair or replace bathroom exhaust fans; develop HVAC operation and maintenance plan; install upper-room UVGI; increase outdoor air supply and air flow; upgrade air filters; develop respiratory protection program
Martin et al. (2014b)	Showers available; clothing available; no isolation of infected clients; ventilation inadequate	*Mycobacterium tuberculosis*	Trained employees and volunteers on tuberculosis symptoms and prevention; screens new clients for tuberculosis	Develop written infection control plan, including tuberculosis and hygiene education; create respiratory separation area for infected clients; repair or replace bathroom exhaust fans; develop HVAC operation and maintenance plan; install upper-room UVGI; increase outdoor air supply and air flow; upgrade air filters; develop respiratory protection program
Mayo et al. (1996)	Showers available; clients taught to use tissues to cover nose and mouth when coughing, sneezing; taught to dispose of tissues properly	*Mycobacterium tuberculosis*, active (8); *Mycobacterium tuberculosis*, latent (27%)	Clients without proof of tuberculosis screening within past six months sleep in segregated area, evicted within in a week if fail to get tested	–

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Table 2 (*continued*)

Study	Hygiene behaviors and environmental health conditions	Reported pathogens and health outcomes	Implemented hygiene and environmental health interventions	Recommended hygiene and environmental health interventions
McElroy et al. (2003)		*Mycobacterium tuberculosis*, active (23); *Mycobacterium tuberculosis*, latent (110, 18%)	Installed large fans to improve ventilation; frequently opens windows and doors to improve ventilation; educated clients and staff on tuberculosis signs and symptoms; uses symptom-screening checklist for clients	–
Misselbeck and Phillips (2005)		*Mycobacterium tuberculosis*, active (16); *Mycobacterium tuberculosis*, latent	Evaluated HVAC system; cleaned and retrofitted AHUs; upgraded air filters; installed UVGI; educated clients about tuberculosis and upgrades; provided staff and visiting nurses with tuberculosis signs-and-symptoms checklists; placed tuberculosis posters in sleeping quarters and shower hallways	–
Nardell et al. (2008)	Showers available; laundry available; overcrowding	Skin, eye symptoms (223, 6%); keratoconjunctivitis (1)	Moved upper-room ultraviolet germicidal irradiation fixture higher on wall	Train staff about safety with UV lamps
Nolan et al. (1991)	Outside air supply inadequate in winter	*Mycobacterium tuberculosis* (26)	Installed UV disinfection system in ventilation units; enforcements for tuberculosis patients noncompliant with directly observed therapy	Improve air disinfection and exchange system
Ottomeyer et al. (2016)	Surfaces including stair rail, light switch, refrigerator handle, telephone, TV remote, door handle, chair handle, toilet flush button, keyboard, computer mouse positive for bacterial growth, negative for MRSA	Methicillin-resistant *Staphylococcus aureus* (MRSA) (28, 10%)	–	–
Stratigos et al. (1999)	Showers available; clothing available; laundry available; foot hygiene inadequate	Tinea pedis (54, 38%); pitted keratolysis of the feet (29, 20%); acne vulgaris (26, 18%); toenail onychomycosis (22, 16%); seborrheic dermatitis (19, 13%); folliculitis (17, 12%); atopic dermatitis (10, 7%); psoriasis (4, 3%); stasis dermatitis (3, 2%); rosacea (2, 1%); abrasions (18, 13%); ecchymoses (10, 7%); diffuse dermatoheliosis (3, 2%)	–	Improve foot hygiene, foot hygiene education; regular skin examinations
Torres et al. (1990)	Overcrowding; ventilation inadequate	*Mycobacterium tuberculosis*, active (30, 18%)	–	UV lights; tuberculosis screening programs

TST = tuberculin skin test; UV = ultraviolet; UVGI = ultraviolet germicidal irradiation; HVAC = heating, ventilation, and air conditioning; AHU = air handling unit.

contagious clients. Two studies (7%) discussed concerns regarding drinking water and sanitation in shelters, including occasional water shortages and barriers to bathroom usage such as prohibitive cost or wheelchair inaccessibility. One of these studies additionally noted water quality was insufficient and there were no toilets at some shelters. Fifteen studies (54%) mentioned clients were able or encouraged to shower; another noted showers were often broken, without water, or not wheelchair accessible. Ten studies (36%) noted shelters provided clients a change of clothes and/or laundry services, while two others found laundry services were sometimes broken or without water. Two studies (7%) observed poor foot hygiene among shelter clients, and a third observed poor personal hygiene more broadly. One study found both handwashing and food-handling practices to be inadequate. Physical objects that raised health concerns were bedding, blankets, and mattresses (n = 5, 18%); floors, carpets, and walls (n = 2, 7%); and personal belongings (n = 1, 4%). Further environmental health concerns in shelters documented in the literature were second-hand smoke exposure (n = 2, 7%), lack of pest control (n = 2, 7%), lack of fire prevention measures (n = 1, 4%), lack of a designated area for diapering infants (n = 1, 4%), and dampness (n = 1, 4%).

3.3. Reported pathogens and health outcomes

Fig. 2 shows potential associations between environmental health conditions and hygiene behaviors and health outcomes documented in the literature. Fifteen studies (54%) recorded *Mycobacterium tuberculosis* infections, either active and latent, among shelter clients. Three of these noted a client had died from tuberculosis (Curtis et al., 2000; Misselbeck and Phillips, 2005; Nolan et al., 1991). Other bacterial infections included methicillin-resistant *Staphylococcus aureus* (MRSA) (n = 1, 4%), *Tropheryma whipplei* (n = 1, 4%), and diarrheal illness (n = 1, 4%). Two studies (7%) recorded asthma or asthma-like symptoms in children staying in shelters. Five (18%) studied skin disease among shelter clients, and one of these found louse-borne relapsing fever and epidemic typhus resulting from skin diseases. Additional health concerns were bed bug bites, generic eye and skin symptoms including keratoconjunctivitis from an ultraviolet germicidal irradiation (UVGI) fixture, and pressure sores among physically disabled clients partially attributed to poor hygiene in a shelter. Five studies (18%) included shelter staff in examinations or health outcome analyses (Curtis et al., 2000; Gross and Rosenberg, 1987; Hudson et al., 2005; Hwang et al., 2005; Nardell et al., 2008). Three of these studies reported shelter staff experienced adverse health outcomes, including diarrheal disease, bed bug bites, and a converted tuberculin skin test (TST).

3.4. Reported and recommended interventions

Five studies (18%) described implementation of ventilation improvements in shelters, including cleaning air handling units (AHUs), improving airflow with fans, increasing outdoor air supply by opening windows and doors, upgrading air filter efficiency within AHUs, and implementing a new heating, ventilation, and air conditioning (HVAC) system. An additional seven studies (25%) recommended similar ventilation improvements without documenting any implementation. UVGI in the form of upper-room or in-duct fixtures within AHUs were installed in four studies (14%) and recommended in another seven (25%). Seven studies (25%) recommended better maintenance of HVAC or UV systems. Other recommended or documented infrastructural interventions included building repairs and removing carpets to eliminate bed bug infestations or asthma triggers. One study recommended improved water, sanitation, and fire safety measures.

Six studies (21%) noted that shelter employees, volunteers, and/or clients were trained on symptoms and prevention of tuberculosis, and a seventh study recommended this. One study suggested similar education be implemented for asthma. Further behavioral health recommendations included cleaning or disinfecting bedding and/or mattresses regularly (n = 2); improved foot hygiene or foot hygiene education among clients (n = 2); improved handwashing behaviors (n = 1); and more frequent clothes changing among clients (n = 1).

Regarding administrative controls, six studies (21%) recommended isolating contagious clients in a designated area of shelters, and one

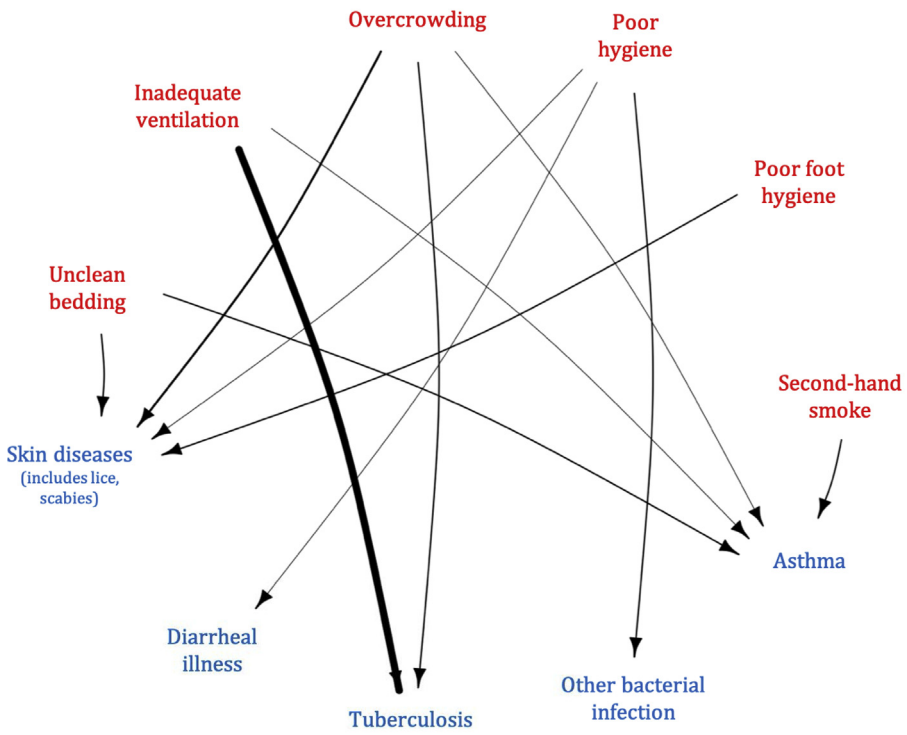

Fig. 2. Environmental health and hygiene exposures (red) and health outcomes (blue) in homeless shelters. Arrows represent potential associations as identified in the literature. Darker lines are indicative of the number of studies documenting this potential association. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

noted clients without proof of a recent TST slept in a segregated area in one shelter. Nine studies (32%) included shelters that required or offered screening of new clients for tuberculosis or another infectious disease, and three further studies recommended this. One study noted that some included shelters had indoor clean air policies and recommended more shelters implement “no smoking areas” or a tobacco-smoking ban on premises.

4. Discussion

4.1. Status of environmental health conditions and exposures

Inadequate ventilation, air flow patterns, outdoor air supply, and other HVAC-related parameters are associated with the airborne transmission of infectious agents in the built environment (Li et al., 2007; Luongo et al., 2016). This is especially important in homeless shelters where people sleep in close proximity and where the tuberculosis positivity is disproportionately high (Beijer et al., 2012). HVAC engineering concerns are common in many facilities functioning as homeless shelters that were not designed or built for that purpose (Committee on Health Care for Homeless People, 1988). Facilities in included studies included a converted office building (Martin et al., 2014a), abandoned warehouse (Nolan et al., 1991), restaurant (McElroy et al., 2003), factory (Nardell et al., 2008), school (Nardell et al., 2008), and church basement (Nardell et al., 2008). Only one study mentioned a facility built specifically to serve people experiencing homelessness; this shelter was characterized as having “state-of-the-art” AHUs and well-maintained ventilation systems (Martin et al., 2014b). Other HVAC concerns were caused by poor operation, including closing ventilation during winter months to minimize heating expenses (Nolan et al., 1991).

Apart from HVAC systems, the status of environmental health infrastructure in homeless shelters was not commonly discussed in the literature. Few studies mention the availability of water, sanitation, showers, or laundry services. While many might assume these services are available to clients in many shelters included in this review, as most are in high-income countries in North America and Europe that have high water, sanitation, and hygiene coverage, in fact the few studies that documented associated findings did not support this assumption. Ho et al. (2007) noted water in a U.S.A. shelter was sometimes cut off and bathrooms and showers were not wheelchair accessible (Ho et al., 2007). As a result, some clients “had given up using the shelter bathroom” and one stated they had not been able to take a shower in three months due to accessibility and safety concerns (Ho et al., 2007). Goel et al. (2017) found water shortages, poor water quality, unhygienic toilets, and a lack of functioning laundry services in shelters in India. Space outside shelters smelled from frequent urination, as many could not afford to pay toilet use fees (Goel et al., 2017). Insufficient access to free and available sanitation facilities among people experiencing homelessness worldwide leads to open defecation and urination, particularly in the environment surrounding homeless shelters (Capone et al., 2018; Stanwell-Smith, 2010). A study mapping over 100 presumptive human stools in Atlanta, Georgia, U.S.A. found 92% of open defecation sites were within 400 m of a homeless shelter or soup kitchen (Capone et al., 2018).

The two studies that note inadequacies in water, sanitation, and hygiene infrastructure were two of three included studies that incorporated open-ended interviews with homeless shelter clients (Goel et al., 2017; Ho et al., 2007). The third publication studied asthma, a health outcome for which water, sanitation, and hygiene infrastructure is less relevant (Buu et al., 2014). Direct feedback from clients may highlight problems missed by researcher observations or conversations with shelter staff or issues deemed not to be important by researchers. Further research incorporating feedback from homeless shelter clients is needed to better understand if their needs are being met by the environmental health conditions in shelters.

Deficiencies in hygiene behaviors in shelters were less frequently discussed in the literature than environmental health infrastructure concerns. A study on diarrheal disease in women's shelters stated that staff caring for both ill and well children while their mothers work may not practice or understand the need for proper handwashing (Gross and Rosenberg, 1987). The risk of foodborne illness is elevated in some shelters where children have unrestricted access to kitchens or clients help prepare dinner without proper hygiene. A study on Indian shelters found inadequate food hygiene in one shelter where clients cook in close proximity to a garbage-dumping site. Several studies mentioned unclean bedding as a hygiene concern and source of bed bugs (Hwang et al., 2005), lice (Brouqui et al., 2005), and asthma triggers (Buu et al., 2014; Lefeuvre et al., 2016).

Overcrowded conditions are associated with increased person-to-person transmission of infections (McNicholas et al., 2000). Some homeless shelters operate at full capacity nightly (Badiaga et al., 2005; Martin et al., 2014b) and over capacity frequently, especially in adverse weather conditions (Martin et al., 2014a, 2013a). Further, they often fail to isolate clients with infectious diseases. In included studies, spacing between shelter beds was as small as twelve inches (30 cm) in one study (Nolan et al., 1991) and up to three feet (1 m) in another that noted mattresses were laid between beds as needed (Curtis et al., 2000). Crisan et al. (2015) found sleeping in close proximity with an infected individual in a shelter was not significantly associated with acquiring tuberculosis, likely because clients moved about freely and used communal spaces (Crisan et al., 2015). Some shelters have additional people visiting or seeking other services in communal spaces during the day (Curtis et al., 2000).

4.2. Reported pathogens and health outcomes

In agreement with reviews on the health of homeless populations, most included studies documented tuberculosis and skin diseases (Beijer et al., 2012; Fazel et al., 2014; Raoult et al., 2001). A large proportion of tuberculosis studies were conducted by the U.S. CDC, which has implemented tuberculosis control efforts through local public health departments across the country. HIV, hepatitis C, hepatitis B, and other bloodborne infections which are common among the homeless population (Beijer et al., 2012; Raoult et al., 2001) were less represented in this review, as these infections are largely associated intravenous drug use. None of the included articles mentioned environmental health conditions or hygiene behaviors related to drug use, such as access to clean needles or sharps disposals. A high prevalence of nontuberculous respiratory infections including influenza and pneumonia has also been observed among the homeless (Plevneshi et al., 2009; Raoult et al., 2001), but were not noted in any included studies.

4.3. Client population, risk factors

Estimates from the U.S.A. reveal nearly 40% of homeless persons identify as women (Henry et al., 2017), yet over one-third of studies included shelters designated for men only compared to a single study including shelters designated for women and children only. Of the remaining studies, all that noted the gender of enrolled clients included more men than women. Homeless women may face additional health and hygiene challenges and risks such as pregnancy and menstrual hygiene management, however, no included studies discussed this (Ensign, 2000; Rimawi et al., 2014). The majority of studies did not mention whether children were present at included shelters; notable exceptions include two studies on pediatric asthma (Buu et al., 2014; Lefeuvre et al., 2016), which has a high prevalence among homeless children (Grant et al., 2007).

Racial minorities, sexual minorities, and disabled persons are overrepresented in the homeless population. Accordingly, some included studies from the U.S.A. noted high proportions of black, Hispanic, and Native American clients (Badiaga et al., 2005; Ho et al.,

2007; Nolan et al., 1991; Torres et al., 1990). With one exception, a study emphasizing the needs of physically disabled individuals (Ho et al., 2007), there were few mentions of physically or mentally disabled individuals or sexual minorities in the included studies. These populations may face stigmatization and challenges in having their environmental health and hygiene needs accommodated in homeless shelters that are not described in the literature (Cochran et al., 2002; Jones, 2016).

Alcoholism and drug use among homeless shelter clients was noted in several studies (Curtis et al., 2000; Misselbeck and Phillips, 2005; Stratigos et al., 1999; Torres et al., 1990). Torres et al. (1990) found over half of enrolled subjects reported active drug use, though none of the included studies mentioned providing additional supports required by this population, such as a clean needle supply or safe sharps disposal (Torres et al., 1990). Stratigos et al. (1999) found over half of enrolled subjects had a known history of alcoholism (Stratigos et al., 1999). In addition to alcohol abuse, Curtis et al. (2000) found malnutrition was common among shelter clients (Curtis et al., 2000). Prevalence of these conditions, as well as tobacco smoking, which is more common in the homeless than in the general population, can lead to health complications and predispose individuals to infections (Badiaga et al., 2008b; Raoult et al., 2001).

A number of studies included shelter clients infected with HIV (Brouqui et al., 2005; Curtis et al., 2000; Hudson et al., 2005; McElroy et al., 2003; Misselbeck and Phillips, 2005; Stratigos et al., 1999; Torres et al., 1990). A 2012 systematic review and meta-analysis found a 0.3–22.1% HIV prevalence in people experiencing homelessness, with a prevalence ratio of 1–77 in homeless people versus the general population in the same country (Beijer et al., 2012). Included studies in the present review found 13–90% of shelter clients with active tuberculosis, frequently 50% or more, were co-infected with HIV. In addition to overall HIV prevalence, Torres et al. (1990) noted a 21% prevalence of syphilis and a 43% prevalence of positive hepatitis B antibodies in enrolled shelter clients (Torres et al., 1990). The prevalence of these sexually transmitted infections in the homeless population place shelter clients at higher risk of adverse health outcomes.

4.4. Reported and recommended interventions

The majority of tuberculosis outbreak studies described implementation of or recommended ventilation improvements and/or UVGI in affected shelters. These are both considered standard environmental controls for tuberculosis (Nardell, 2016). Few included studies presented evidence these systems helped control or prevent outbreaks. One study found cleaning and retrofitting AHUs reduced respiratory complaints among clients (Misselbeck and Phillips, 2005) and another noted a nearby shelter with a UV system saw fewer secondary cases of tuberculosis than the studied shelter with tighter bed spacing and without a UV system. There was a mixture of upper-room UVGI in high-risk rooms as well as in-duct UVGI within HVAC systems in included studies. Some practitioners and researchers have raised health concerns regarding the impact of upper-room systems on the eyes and skin. In response, Nardell et al. (2008) conducted a double-blind, placebo-controlled study of upper-room UVGI at 14 shelters over seven years and found no statistically significant difference in reported skin or eye symptoms (Nardell et al., 2008). However, authors did note an incident of UV-related keratoconjunctivitis from a fixture installed too close to beds, and another incident of elevated risk when maintenance staff at one shelter dusted fixtures while they were turned on. This study highlights that while UVGI systems are safe when used properly, it is important for shelter staff to be trained on safety protocols.

Administrative controls should be implemented in conjunction with infrastructural and behavioral interventions to improve and protect the health of shelter clients. Misselbeck and Phillips (2005) described the City of St. Louis Health Department's system to track the movement of homeless clients through the city's shelter network in order to identify, find, evaluate, and treat tuberculosis contacts (Misselbeck and Phillips, 2005). This is especially useful when clients spend consecutive nights at different shelters and can transmit infectious agents between shelters if contagious or carrying vector-infested belongings (Hwang et al., 2005). Screening clients using symptoms checklists or “TB cards” with TST results and working closely with local health departments were common themes in tuberculosis outbreak studies. Bass et al. (1990) presents an example of a partnership between a family homeless shelter and a hospital-based clinic to implement pre-entry medical evaluations for shelter residents, which effectively prevented secondary infections at the shelter (Bass et al., 1990). In addition to screening clients, the U.S. CDC advises homeless shelter staff and volunteers be screened for tuberculosis when they start work and every 6–12 months thereafter, though this was not mentioned in included studies (Centers for Disease Control, 1992). One included study recommended increased collaboration on tuberculosis screening with local jails where people experiencing homelessness are frequently incarcerated (McElroy et al., 2003).

4.5. Obstacles to improving environmental health conditions

The transience of homeless shelter clients makes studying, treating, and intervening in this population difficult. There is loss to follow-up in epidemiological studies and medical treatment regimens and obstacles to implementing longitudinal education programs. Brouqui et al. (2005) noted in a four-year investigation, only 48 clients (5%) were observed two or more times and stated the turnover rate “may complicate any educational program” (Brouqui et al., 2005). Buu et al. (2014) similarly noted turnover of shelter clients as well as staff means “frequent trainings would be necessary to maintain basic knowledge levels” in regards to a potential asthma education program (Buu et al., 2014). While a number of included studies documented implementation of or recommended health education programs within shelters, none gave details about how such programs were or should be carried out.

Many homeless shelters rely on donations, non-profit organizations, and government grants for continued operation and face financial constraints in improving environmental health conditions. Infrastructural interventions may be prohibitively expensive. For example, Hwang et al. (2005) found the total cost for bed bug control at affected shelters averaged U.S.$3085 per shelter with a maximum of U.S.$15,000 (Hwang et al., 2005). Misselbeck and Phillips (2005) noted a UVGI system cost one shelter U.S.$25,000, and the process of obtaining this funding and getting proper approval was time consuming for staff who are often already overworked (Misselbeck and Phillips, 2005). Buu et al. (2014) stated that while staff “have a strong desire” to eliminate asthma triggers at one shelter, their schedules make it difficult to properly clean rooms, and economic constraints force them to rely on donated furniture that may not be hygienic (Buu et al., 2014). Meanwhile, parents staying in homeless shelters with asthmatic children have little control over their living environment and find it difficult to minimize asthma triggers in these settings (Buu et al., 2014; Lefeuvre et al., 2016).

4.6. Information gaps and limitations

Except one study of shelters in India, there were no studies conducted in low- or middle-income countries. Several included American and French studies had overlapping authorship, and many American studies involving tuberculosis outbreaks were motivated by local public health agencies.

Beyond North America and Europe, homelessness may be defined and managed outside of the context of a “homeless shelter.” In seeking a broad, globally applicable definition, the Institute of Global Homelessness characterizes homelessness as “lacking access to

minimally adequate housing," which encompasses persons without any accommodation, living in temporary or crisis accommodation, or living in severely inadequate or insecure accommodation (Busch-Geertsema et al., 2016). While outside the scope of this review, for more information regarding environmental health and inadequate housing, see references (Braubach and Fairburn, 2010; Gibson et al., 2011; Jacobs, 2011).

Because homeless shelters serve a primarily transient population, it was not uncommon for studies to note participants were lost to follow-up or could not be enrolled. This characteristic of homeless shelters also presented difficulties in discerning an exact number of clients who may have passed through shelters or been exposed to an infectious case for purposes of reporting incidence rates. This limitation, as well as others such as self-selection bias resulting from the sampling methods employed in several studies (Gross and Rosenberg, 1987; Stratigos et al., 1999; Torres et al., 1990), makes it difficult to generalize findings from a single study or subset of studies to other shelters. Furthermore, our review did not incorporate homeless populations who live on the streets or otherwise outside of a shelter environment, though these individuals may visit a shelter or seek other services there. This population is likely exposed to different adverse environmental health conditions or barriers to maintaining adequate hygiene practice. Studies have found people experiencing homelessness who sleep on the street or in open spaces report poorer personal hygiene practices and less access to water, sanitation, and hygiene facilities relative to those who utilize shelters (Leibler et al., 2017; Neves-Silva et al., 2018; Uddin et al., 2016). While many studies claimed an association between environmental health conditions and hygiene behaviors of clients and staff within a shelter itself, it is difficult to disaggregate the impact of the shelter environment from the lifestyle of the homeless population more generally.

4.7. Limitations of the review

Many included studies were descriptive cross-sectional studies and were unsuitable for establishing a causal relationship between environmental health conditions and health outcomes for homeless populations in shelters. A few studies did not distinguish between the health outcomes and environmental health conditions and hygiene behaviors experienced by short-term clients relative to long-term clients, such as those too injured or sick to work, in a rehabilitation program, or military veterans, who may be served with a higher standard of care. The search strategy did not include disease-related key words, which may have excluded articles about health outcomes or outbreaks that described environmental health conditions and hygiene behaviors but did not have a related key word. Only studies written in English were included in the review.

5. Conclusion

This systematic scoping review demonstrates inadequate homeless shelter conditions and associated health outcomes for this marginalized population. Insufficient ventilation systems, unhygienic bedding, and overcrowding are frequently documented concerns in the literature. Involvement by national and local authorities to inspect and monitor these facilities according to guidelines for minimum essential environmental health conditions can create incentives for incremental improvements. Further research on environmental health and hygiene interventions, particularly research that addresses concerns of vulnerable populations such as women and children, racial minorities, sexual minorities, and disabled individuals, or research that incorporates direct feedback from shelter clients, is needed to more fully assess how the needs of this population are being met and to identify improvement opportunities. Investment in improving environmental health conditions and hygiene behaviors in homeless shelters will protect and promote the health and well-being of people experiencing homelessness.

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Appendix A. Supplementary data

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