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Ergonomic exposures and control measures associated with mass fatality decedent handling in morgues and body collection points in a New York healthcare system during COVID-19: A case series

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ARTICLE INFO

Keywords:
Musculoskeletal injury
Morgue
Dead
Expired
Mortuary
Deceased
Funeral
Charnel
Mortem

ABSTRACT

Introduction: In April 2020, novel coronavirus SARS-CoV-2 (COVID-19) produced an ongoing mass fatality event in New York. This overwhelmed hospital morgues necessitating emergent expansion of capacity in the form of refrigerated trucks, trailers, and shipping containers referred to as body collection points (BCPs). The risks for musculoskeletal injury during routine and mass fatality mortuary operations and experiences of decedent handlers throughout the ‘first wave’ of COVID-19 are presented along with mitigation strategies.

Methods: Awareness of the high rates of musculoskeletal injury among health care workers due to ergonomic exposures from patient handling, including heavy and repetitive manual lifting, prompted safety walkthroughs of mortuary operations at multiple hospitals within a health system in New York State by workforce safety specialists. Site visits sought to identify ergonomic exposures and ameliorate risk for injury associated with decedent handling by implementing engineering, work practice, and administrative controls.

Results: Musculoskeletal exposures included manual lifting of decedents to high and low surfaces, non-neutral postures, maneuvering of heavy equipment, and push/pull forces associated with the transport of decedents.

Discussion: Risk mitigation strategies through participatory ergonomics, education on body mechanics, development of novel handling techniques implementing friction-reducing aides, procurement of specialized equipment, optimizing BCP design, and facilitation of communication between hospital and system-wide departments are presented along with lessons learned. After-action review of health system workers’ compensation data found over four thousand lost workdays due to decedent handling related incidents, which illuminates the magnitude of musculoskeletal injury risk to decedent handlers.

1. Introduction

Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) that causes coronavirus disease 2019 (COVID-19) is a global, infectious, pandemic disease (Disser et al., 2020). Currently, it has been linked with over four million deaths in about two hundred countries (Okafor and Chia, 2021; The Visual and Data Journalism Team. Covid map: Coronavirus cases), including over six hundred thousand deaths in the United States (Johns Hopkins University and Medicine Coronavirus Resource Center. Data in Motion. 2021: https://coronavirus.jhu.edu/Last accessed August 30).

In a study using mortality data from 2014 to 2019 to estimate expected (all-cause) deaths in the U.S. from March 2020 to January 2021 (Woolf et al., 2021), authors found that 2,801,439 deaths had occurred, nearly 23% more than expected, representing 522,368 excess deaths that year. Deaths substantially exceeded recent, annual, all-cause mortality increases of <2.5%; deaths attributed to COVID-19 accounted for about 72% of excess deaths. The authors also reported that excess deaths not attributed to COVID-19 might reflect immediate or delayed mortality from undocumented COVID-19 or non-COVID-19 deaths secondary to COVID-19, such as delayed medical care (Woolf et al., 2021).

New York City (NYC) was an initial epicenter of COVID-19 in the United States of America (Thompson et al., 2020). Northwell Health is the largest healthcare provider in New York State (NYS). The health...
system includes 23 hospitals and over 800 ambulatory care centers serving an area of nearly 11 million people. It treats more than 2 million patients annually (Northwell Health Fact Sheet, May 2020). Northwell Health has over 75,000 team members, including over 3800 physicians and 18,500 nurses. Thus, the rise in the death toll due to COVID-19 was acutely experienced by personnel throughout the health system.

At the onset of COVID-19, defined here as of March 01, 2020 (AJMC, 2021), healthcare facilities throughout the health system were faced with unprecedented levels of mass fatality and decedent handling, sustained for months while the pandemic surged in NYS. This was in addition to continuing to respectfully process individuals who had died from other leading causes of death, such as heart disease and cancer.

By early April 2020, death associated with COVID-19 in NYC had overwhelmed morgues and funeral homes. Decedents filled storage spaces in hospitals, medical centers, and long-term care facilities to capacity, exhausting their ability to store bodies safely. Hospitals took emergent action throughout NYG and surrounding counties to rapidly expand capacity. Temporary refrigerated units, known as “Body Collection Points (BCPs),” were procured to meet capacity demands. BCPs can take many forms, including refrigerated containers, trucks, semi-trailers, and surge spaces with heat exchange systems.

1.1. Decedent handling exposures

Characteristics of decedent handling have parallels to total assist and dependent patient handling, which have well-documented risks of musculoskeletal injury to healthcare workers (Robielos et al., 2018). Musculoskeletal hazards of patient handling include non-neutral postures, poor coupling, high, unstable loads, time demands and repetitive movements. Psychosocial exposures include high effort, low control, and staffing shortages (Ito et al., 2014; Schroder and Nienhaus, 2020; Simon et al., 2008). Additionally, decedent handling is associated with other exposures, such as constrained work environments, weather-related conditions (heat, cold), and, in BCPs, lifts to and from the floor and surfaces above or below shoulder height.

Decedents are maintained in refrigeration to delay decomposition (Pobari and Obiechina, 2021). Cold temperature storage changes tissue properties and rigidity (Wescott, 2019). To this extent, decedent handling may also have similarities to mechanical exposures associated with manual material handling (MMH) (Petit et al., 2016). For example, one similarity between decedent handling following refrigeration and MMH exposures is the potential of handling heavy, rigid, bulky loads (NIOSH, 2007).

Decedent handlers are also exposed to biological hazards. Although there is currently no evidence of COVID-19 transmission from deceased bodies, there is a possibility of virulent SARS-CoV-2 persistence in the pulmonary system of deceased individuals who had died from COVID-19 (World Health Organization, 2020; Patel et al., 2020). Thus, the risk of infection could occur at autopsy or during decedent handling from contact with bodily fluids. Moreover, if body bags are poorly designed, handlers may have to support the decedent’s weight by positioning their hands underneath the body bag to minimize body bag tears; this may further increase mechanical exposures while simultaneously increasing the risk of contamination (Patel et al., 2020). Bodybag tears during decedent handling represent a vector for infection spread.

1.2. Health hazards

One review on health hazards in mortuary services found that along with mechanical, chemical (e.g., formalin, dyes), physical (e.g., electrical shocks, burns), and biological (e.g., fungi, bacteria, viruses, allergic reactions) stressesors related to working with cadavers, morticians are often exposed to safety hazards, such as slips, trips, and falls, and psychosocial stressors such as job stress (Pobari and Obiechina, 2021). In addition, autopsy and mortuary technicians were found to have more symptoms of post-traumatic stress disorder (PTSD) and emotional exhaustion. Psychological exposures include postmortem identification of remains, sounds (e.g., cutting of bone), smells (e.g., decomposing remains), and visuals associated with the performance of decedent handling, and autopsy (especially among child decedents), and interaction with the bereaved (Komur et al., 2017; McCarroll et al., 1995; Ursano and McCarroll, 1990).

1.3. Case series background

In April of 2020, safe patient handling and ergonomic specialists within the health system’s Workforce Safety (WFS) department partnered with shared service departments within the health system. The purpose of this partnership was to investigate the health and safety implications of rising death tolls and procurement of BCPs to decedent handlers. Risk of musculoskeletal injury during decedent handling was empirically extrapolated from awareness of the known injury risks inherent during similar patient handling tasks. The use of lifts, friction reduction devices, and other risk mitigation aids and strategies were not widely known or available within decedent handling workflows.

1.4. Objectives

Given these gaps in information around mitigation strategies, the objectives of this case series are to (a) Document decedent handling processes and experiences of decedent handlers during the surge of COVID-19 at five hospital locations within the health system; (b) Identify decedent handling exposures during site visits; (c) Contrast routine and mass fatality decedent handling operations; (d) Identify and discuss controls implemented in real-time during site visits; (e) Discuss lessons learned and identify future considerations for emergency planning and management during mass fatality events as it relates to decedent handling.

2. Methods

In April 2020, workforce safety specialists collaborated with multiple hospital facilities throughout the Northwell Health system to organize on-site hazard identification of decedent handling spaces and work practices. Participatory ergonomics was encouraged; often, issues were identified, and frontline decedent handlers posed appropriate solutions. Recommendations were made to augment safety measures already implemented by frontline decedent handlers. This included education on body mechanics and friction reduction aids/slide sheets and equipment and lifts to reduce strain during handling tasks. In cases where construction and design of the BCPs were discovered in hindsight to be less than optimal, temporary workaround and permanent solutions were discussed and implemented collaboratively. For example, hazard identification found patterns of BCP shelf designs where manual handling could be further minimized with specialized equipment. This was quickly conveyed, and system-level procurement of powered scissor lifts and re-purposed emergency medical service (EMS) stretchers were distributed as needed. The information presented was gathered during this process of hazard identification, education, and risk mitigation through walkthrough assessments. Furthermore, an after-action review of workers’ compensation (WC) claims data is presented to illustrate the link between exposures and injury.

The information collected for this case series was performed as part of our health system’s COVID-19-related service and quality improvement process. It was thus designated ‘not human subjects research’ by our Institutional Review Board.

2.1. Workflow and musculoskeletal exposures

Dedecent handling workflow in hospitals is nuanced. Handling actions and techniques, equipment utilized, space and layout of morgue and BCPs varies between facilities. Decedent handling workflow from
Movement of an expired patient from medical units to the morgue or BCP involves multiple decedent handling (direct interaction with the decedent) and transport (operating/maneuvering surface on which the decedent is resting, such as a stretcher) actions. Five to ten decedent handling and transport actions are necessary to respectfully process each expired patient. Each action represents a musculoskeletal exposure with an attendant risk of injury to decedent handlers. Exposures such as repetitive lifting or non-neutral postures may not always result in injury (or may be below the threshold for the team member to report).

2.1.1. Direct decedent handling

- Lateral transfers (lateral pull, push or lift).
- Rolling/turning (rotation of a supine patient along the vertical axis).
- Repositioning (adjustments in the supine position to the center on transport equipment).
- High/low lifts (transfer between different surface heights, initiated or terminated above shoulder or below knee height) which may be performed manually or using equipment.

2.1.2. Transport of the decedent

- Pushing/pulling to maneuver equipment
- Operation of lifts

Hand-off of the decedent and personal effects occurs between clinical (involved in treatment and diagnosis e.g. nurse/nursing assistant) and non-clinical (support patient care including e.g. transporter, security, morgue attendant) health care workers (Santiago, 2020). Involvement in decedent handling spans multiple departments, job titles, training, and education backgrounds which was variable between facilities.

2.2. Workers’ compensation claims data review

Investigation of injury data was conducted after on-site risk identification and mitigation walkthroughs were conducted. Claims data from June 2013–July 2021 was filtered to remove controverted claims. Injury descriptions were screened for the following keywords: dead, deceased, departed, expire(d), corpse, morgue, funeral, morgue attendant, trailer, autopsy, BCP, and medical examiner (Table 1 & Fig. 2).

Table 1
Self-reported injuries and exposures associated with decedent handling at Northwell Health between 2013 and 2021 (N = 62)².

| Injury or Exposure, n (%) | Exposure (Event) |
|--------------------------|-------------------|
| Injury | Task | Sprain, strain, or tear | Bruise, inflammation or dislocation | Struck against or by | Caught in, under or between | Cat, puncture or laceration |
| Decedent Handling | 37 (60) | 9 (-) | 12 (20) | 7 (11) | 6 (10) |

² N = 62: three cases were linked with (a) absorption, ingestion, inhalation, (b) skin diseases, and (c) other than a physical cause. The percentage does not add to 100% due to the rounding of decimals.

¹ Strain, sprain, tear to musculoskeletal system: Occurred by holding, carrying, lifting, pushing, pulling, or rotating the trunk. These mechanical exposures are collectively termed “decedent handling exposures.”

² Bruise injuries are associated with struck against or by, or caught in, under, or between. Inflammation is associated with struck against or by. Dislocation is associated with sprains, strains, or tears. No percentage is given in this cell, as it is reflected in the aforementioned injuries and exposures.

³ Struck against or by: Occurred by falling or “flying” object, struck by an object being lifted or handled, tipping or sliding of an object, or striking against or stepping on a sharp object.

⁴ Caught in, under, or between: Caught in, under, or between an object and the distal upper extremity.

⁵ Cut, puncture, laceration: cut, puncture, or laceration by an object.

¹ Force generated by the musculoskeletal system without the use of assistive equipment.

² Controverted claims are contested or denied by the insurer/employer because the cause of injury was not work-related or the employee was not injured to the extent claimed.
3. Results in a case series: exposures, experiences, management & best practices

3.1. Hospital A – Tertiary care facility

The hospital morgue consists of a walk-in refrigerator with a capacity for 12 decedents. Decedents and remains are stored on two-tiered cadaver stretchers designed to be used with standard stainless steel body trays. The hospital morgue performs autopsies with two stations and wall-mounted sinks.

3.1.1. Routine decedent handling workflow

Decedents are placed into body bags on the medical units by nurses (RN) and nursing assistants (NA). The decedent is transferred onto a covered cadaver carrier, and then transported to the morgue by NAs and transporters. Hand off occurs to morgue attendants (during the day) or security personnel (evening or nights). Patient identity is verified and documented at the morgue. The patient’s toe tag is checked to ensure it matches the wrist identification band and exterior bag and freezer tag. Personal belongings are stored with the decedent. A transfer from the covered cadaver carrier (i.e. transport stretcher from the medical units) to the cadaver stretcher with body tray occurs either laterally (top tier) or with a low lift (the covered cadaver carrier does not lower to the height of the lowest tray on the cadaver stretcher). The decedent is then wheeled into the walk-in refrigerator. If an autopsy is scheduled, the decedent is transferred onto the shelf. A process of sorting decedents by weight was performed.

3.1.2. Mass fatality decedent handling workflow

In March of 2020, Hospital A’s mortuary and pathology department began to see a substantial increase in decedents due to the COVID-19 pandemic. As a result, storage capacity was expanded by 4–6 decedents in the bereavement room adjacent to the morgue in collaboration with engineering to install cooling units. Ongoing safety improvement through engineering controls were implemented with procurement of equipment and modification of BCP design. In the first BCP, a single-tier shelf was constructed to expand capacity and reduce floor transfers. The initial shelves were constructed higher than the maximum height of the stretcher used for transfers from the morgue to the BCP. Manual lifts of 3–5 inches were required to place decedents onto the shelf. A process of sorting decedents by weight was introduced. Bariatric decedents remained in the morgue, average weight decedents were placed onto the BCP shelf, and remaining decedents were placed onto the tarp-covered floor below. All decedents were oriented perpendicular to the walkway to optimize capacity while avoiding stacking to preserve dignity.

Although it was determined the shelf height in the first trailer could be better optimized to reduce manual lifting, lessons learned could only be applied to subsequent BCPs’ design, as existing trailers filled very quickly, preventing revisions. (See Appendix for BCP design considerations.) Within two weeks, the census of decedents rose rapidly, from 32 at the end of March to 117 in mid-April. A third refrigerated semi-trailer was procured to expand capacity to meet rapidly rising decedent counts. Hospital A used refrigerated 53 ft semi-trailers docked at the loading bay approximately 200 feet from the internal morgue (where all decedents were initially received). The initial BCPs did not have shelving constructed. Instead, decedents were placed respectfully side by side onto a tarp on the floor oriented horizontally. Floor transfers of decedents required a high degree of manual handling, including controlled lowering and low lifts, pushing, and pulling. Initial attempts to use a floor based total assist lift were found impractical by decedent handlers due to the confined spaces and grooved floors in the semi-trailers.

As additional BCPs were procured, shelf designs would incorporate lessons learned from previous BCPs. Powered scissor lifts (Fig. 3) and lightweight mortuary cots (Fig. 4) were procured to reduce manual lifting.

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3 Hospital A was the only site surveyed with morgue attendants. At other facilities, decedent handling in morgues and BCPs was conducted primarily by security personnel.
handling during high and low lifts onto shelving. Shelves in BCP#3 (Fig. 5) were designed to be more amenable to the new equipment, specifically the mortuary cots which could raise to a height of 32in and lower to 6in. The powered scissor lift was helpful for high lifts (especially bariatric decedents). However, the lighter weight and more maneuverable mortuary cots were preferred by morgue attendants to transport decedents from the morgue to the BCPs in the loading dock. The pathway passed through narrow corridors with moderate foot traffic from hospital personnel. Swinging doors to the loading dock exit also represented an egress challenge when maneuvering decedents on transport equipment.

Throughout April, May, and June 2020, the decedent census remained high. Front line handlers developed and implemented new work practice controls. An example was a technique for transferring the decedent off the mortuary cot onto the BCP shelving known as a J-Transfer (Fig. 6). This maneuver was unique to Hospital A due to shelving design and placement of decedents perpendicularly. To perform the J-Transfer, handlers would position the mortuary cot at a slight angle with minimal gap between the cranial end of the mortuary cot and the shelf while allowing space for handler B to stand to the side. Handler A would stand at the head of the cot. With coordinated effort, handlers A and B would slide the decedent off the cot with handler A guiding the decedent to make a 90° turn onto the shelving. Handler B minimized rotation forces to their spine by adopting a wide stance with the left hip externally rotated and utilizing legs to rotate the pelvis in the direction of the transfer. This technique would continue to be used in subsequent BCPs at Hospital A.

3.1.3. Management and best practices

Practices evolved to incorporate lessons learned during the surge in decedent handling at Hospital A. Among management strategies and controls not already discussed, a review of body mechanics was...
conducted in collaboration with onsite Safe Patient Handling & Mobility (SPHM) personnel in April 2020. Friction-reducing plastic slide sheets typically used for patient mobility tasks were introduced. These were placed underneath body bags to aid in lateral and J-transfers and subsequently incorporated into additional work practices.

Morgue attendants at Hospital A also developed ways to use the manual controls on mortuary cots to tilt them into Trendelenburg (trend) positions (i.e., declined angles, Fig. 7) to assist with transferring onto shelves of variable heights (Fig. 8) beneath the maximum height of the stretcher. Slide sheets were placed beneath decedents and kept underneath the patient during transit to the BCP; the decedent was secured with belt buckles to prevent unplanned movement. Once the cot was positioned in the BCP, handlers would trend mortuary cots, and decedents could be carefully maneuvered onto lower shelves with substantially reduced friction from slide sheets and FRP-lined shelves. This trendelenburg positioning technique developed by morgue attendants was also adapted to transfer decedents off covered cadaver carriers (from hospital units) onto lower shelves of cadaver stretcher trays (for storage in the walk-in refrigerated internal morgue). Recent research has found that use of trend during bed repositioning has been found to reduce spinal compressive forces at L5/S1 and peak hand forces below injury thresholds. This effect was suspected to be amplified when used in conjunction with friction reducing aides (Zhou and Wiggermann, 2021).

Additionally, the morgue attendant team increased the use of floor-based total assist lifts with repositioning sheets to lift patients in the morgue, particularly those on lower-tier cadaver stretcher trays. Techniques developed during high-frequency decedent handling continued as part of the handlers’ work practices after the initial surge.

Decedent handlers recall substantial physical and mental fatigue after shifts with high volume decedent handling, especially in the initial stages of the pandemic when processes were being developed through trial and improvement. Additional staffing was secured to assist with decedent handling to alleviate some strain. In addition, morgue attendant team members reported routine rounding by mental health professionals and open discussions during huddles of available psychological services. There was a shared culture of safety and mutual support between morgue team members, transporters, clinical teams, administration, engineering, SPHM, and other services throughout the hospital. As one morgue attendant described, “having each other’s backs” and “finding opportunities to laugh with each other despite everything we were all going through” was meaningful.

### 3.2. Hospital B – Community hospital

The morgue at Hospital B was re-designed from lessons learned during COVID-19. Prior to the renovation, the morgue consisted of a walk-in refrigerator with two sets of 4-tiered shelving and an overhead lift system. Due to the relatively low clearance of the ceiling and design of the lift, it could only be used for mid-low tier shelves. As a result, manual lifting of decedents on trays would routinely occur to reach the higher shelves. Autopsy procedures were also performed in the internal morgue, which would require movement onto and off shelving to the autopsy trolley with manual lifting.

The redesigned morgue consists of a walk-in refrigerator with space for eight decedents on four tiers of shelves on either side. Shelves are lined with friction-reducing (PVC) material. Shelf heights were also designed to work with a powered crematory lift with ball bearings procured during the COVID-19 surge. This lift was used for transfers in the BCP and morgue.

#### 3.2.1. Routine decedent handling workflow

Decedents are placed into a body bag on medical units by RN/NAs. The decedent is laterally transferred onto a stainless-steel body tray on top of a covered cadaver carrier. Cadaver carriers are wheeled to the morgue, where security officers perform subsequent decedent handling and care. Documentation for decedent identification and belongings and location for storage is determined. The decedent along with the body tray is transferred from a covered cadaver carrier onto a crematory lift, which is adjusted to the appropriate height shelf in the walk-in refrigerator. A lateral transfer is performed with the tray onto shelving.
Security personnel handle releases to FD and ME after verification of identity. The decedent is removed from the walk-in refrigerator using the crematory lift, lowered to the FD or ME’s gurney height, and laterally transferred from the body tray to the gurney.

3.2.2. Mass fatality decedent handling workflow

In late March 2020, Hospital B procured an external refrigerated container as a BCP in preparation for increased decedents. The container was placed approximately 200 feet from the internal morgue. An awning for privacy was constructed outside the BCP. Site engineers provided electricity and lighting within the BCP and coordinated with a third-party construction group to build three-tiered metal shelving on both sides along the length of the container (Fig. 9). The shelf was constructed with PVC lining for friction reduction and improved sanitization. Two to three security officers were used to release decedents to FD and ME’s from the BCP.

No precedence existed for the rapid construction of ad-hoc shelving in the BCP at Hospital B. As a result, the shelf heights were not optimal for decedent handlers, given their existing patient transport equipment. The top tier of the shelf was 68 inches high, the middle was 50 inches, and the bottom level was 10 inches (Fig. 9). The ergonomic stressors of this design were quickly identified; however, due to the high number of decedents filling the morgue, there was no time to modify shelves. (See Appendix for BCP design considerations).

As a temporary solution, a powered stretcher procured from local emergency medical services (EMS) was fitted with a wooden platform to increase its maximum lift height to accommodate the middle shelf in the BCP (Fig. 10). The modified EMS stretcher was used until it was replaced by a powered crematory lift with ball bearings which could accommodate the highest shelves to optimize transfers within the BCP and redesigned internal morgue (Figs. 11 and 12). The crematory lift is a form of scissor lift designed for movement of body trays and caskets. Ball bearings on the surface differentiate this from the powered scissor lift pictured in Fig. 3. These reduce friction to allow multidirectional movement during decedent transfers.

Hospital B performed decedent transfers almost exclusively by placing decedents onto body trays due to early experiences with tearing of body bags. Body trays are stainless steel trays with handles. Standard size is 23 inch width x 78 inch length (increasing width for bariatric cases). Use of body trays adds rigidity and structure (which improved the predictability of the lift); improved coupling with handles and reduces risks of tearing body bags. Fluids in the event of a leak are also contained within the tray which can be sanitized. Drawbacks to use of body trays include additional weight and fixed size of the tray.

The crematory lift was designed to be used with such trays. It had a lever to raise the tray approximately one inch so ball bearings would not be in direct contact with the tray. This created a stable platform when transporting and lifting the decedent. The lever was rotated to set the
tray on the ball bearings facilitating the transfers of decedents from body trays to PVC-lined shelves (Fig. 13). Decedent handling in the BCP and internal morgue consisted primarily of lateral transfers with handlers standing at the head and foot due to space constraints in the center walkway (Fig. 14).

As with other facilities, this team also practiced thoughtful arrangement of decedents to reserve space on middle shelves for bariatric decedents throughout the mass fatality surge. Increased personnel were also used to maintain normal hospital security operations, as decedent handling for security staff quickly became a time and personnel-intense task.

3.2.3. Management and best practices

In April 2020, congestion with funeral homes and medical examiners produced a backlog of decedents at Hospital B during a week-long span. The situation required immediate action to prevent overflow in the BCP. This situation was alleviated in collaboration with social work, patient access services, and the county office of emergency management to “decompress” the BCP. In addition, administrative processes were revised to increase monitoring of hospital census for indications of spikes in mass fatality and ongoing BCP capacity management.

Management of infection risk during COVID-19 was also of paramount importance and a critical factor in material choices of the BCP and morgue shelf construction. Instead of wood, PVC and aluminum were selected to improve sanitization with ultraviolet light (Tru-D System) and Viralex Solution. Personal protective equipment (PPE) was appropriately used throughout the handling process, and no incidences of COVID-19 infection were reported during the surge among security team members. Use of body trays for most decedent transfers also reduced likelihood of exposure due to body bag tears.

Most security team members who conducted the decedent handling at Hospital B were former law enforcement officers or first responders with emergency management backgrounds. This training instilled a shared mental model that promoted a mindset of safety, situational awareness, and duty, which was part of the culture among decedent handlers at Hospital B. This background was also instrumental in acclimation to both mental and physical stressors of mass fatality handling. Regarding safety, one security officer said, “That’s a mindset first responders always have, and it never leaves”—Security Officer, Hospital B.

A mental health and therapeutic space, known as the “tranquility
3.2.3.1. **Bariatric decedent handling case.** In-house SPHM specialists worked with decedent handlers to develop solutions to unforeseen hazards and bariatric decedent handling exposures. A bariatric patient (approx. 700lb) expired in the emergency department (E.D.) in one particularly challenging case. Initial efforts to reposition the decedent into a body bag were unsuccessful; there was concern that further measures would be unsafe, as the decedent had shifted substantially and was in danger of rolling off the stretcher. SPHM team members arrived to assist with the transfer. A second stretcher was prepared with a bariatric repositioning sheet underneath a body bag and positioned next to the decedent’s stretcher. The decedent was rolled and laterally transferred from the E.D. stretcher into the bariatric body bag on the adjacent cadaver carrier stretcher using slide sheets and slide boards. The team used a 1000lb capacity lift with the repositioning sheet to raise the decedent and place him onto the crematory lift prepared with a body tray. The decedent was then wheeled into the center aisle of the morgue for holding until he was released. Collaboration between decedent handlers and SPHM personnel at Hospital B reduced many manual handling risks associated with decedent handling.

3.3. **Hospital C – Tertiary care facility**

3.3.1. **Routine decedent handling workflow**

The morgue at Hospital C consists of a refrigerator with ten slide-out trays. Like hospitals A & B, the expired patient is placed into the body bag by RN and NAs on the medical units and transferred onto a covered cadaver carrier (i.e. transport stretcher). Security personnel are notified to rendezvous at the morgue where the decedent and belongings are verified and documented. At least two personnel perform transfers of the decedent from the stretcher onto a slide-out tray. Slide-out trays above or below waist height require a secondary transfer from the stretcher onto a powered crematory lift to be raised or lowered to the level of the appropriate tray. Security team members perform releases to FD and ME’s after identity verification.

3.3.2. **Emergent decedent handling workflow**

In late March and early April of 2020, the rise in decedents spiked sharply at Hospital C. As a result, the internal morgue filled rapidly to capacity. Additional decedents were cooled and maintained using appropriate thermoregulation methods until the arrival of refrigerated containers for use as BCPs. Containers were placed approximately 100 ft from the internal morgue. In-house engineering services constructed shelving. Shelves were two-tiered (top 35 inch, bottom 8 inch). Surfaces were lined with Plexiglas to improve disinfection and reduce the risk of body bag abrasion and tearing during transfers. Plexiglas was durable and served these purposes; however, body bags were difficult to slide, especially when wet (See appendix for BCP design considerations).

Decedents and belongings to be placed in the BCP were carefully cataloged at the internal morgue following standard procedures. The covered cadaver carriers from medical units were initially pushed from the morgue directly into the BCP via a ramp. Then, the team performed a lateral transfer onto the top shelf. The lowest adjustable height of the stretcher was above the height of the bottom shelf. As a result, a controlled manual lowering by security team members was required to place decedents on this shelf.

The security team volunteered to take responsibility for all decedent handling within the BCP to distribute and limit physical strain on clinical team members. After the team completed the transfer, the covered cadaver carrier was returned to clinical team members who waited by the doors leading to the BCP. Clinical healthcare workers would then disinfect the stretcher before bringing it back to the floors for subsequent decedent transport.

As decedent counts rose throughout March and April, local EMS and corporate workforce safety services provided two powered EMS stretchers and a powered scissor lift to reduce manual lifting and lowering, especially to the lower shelves. These engineering controls changed the process. After standard documentation in the morgue the decedent was laterally transferred onto one of the powered lifts/stretchers. Clinical team members could then immediately sanitize the covered cadaver carrier and return to the floors.
This streamlining was helpful in multiple ways. First, it allowed clinical healthcare workers to return to the floors much quicker at a time when all-hands were vital. Second, it permitted security team members to work under less time pressure. Controlled work pacing was necessary to ensure error-free record keeping and reduce the risk for musculoskeletal injury. As the BCPs filled, to a peak of 173 decedents, it became a time-intensive task to perform documentation and double-checks to ensure bodies and belongings were properly accounted for. Careful arranging of decedents occurred to optimize the BCPs for occupancy while maintaining the dignity of decedents. Thirdly, the process reduced exposure to emotional and physical stressors among clinical team members. “We could see it was getting to the nurses, and our officers tried their best to help.” - Security Officer, Hospital C.

The physical task of transferring decedents in the BCP involved two security personnel who would maneuver the powered stretcher/lift into the BCP. The walkway was wide enough to accommodate the positioning of decedent handlers to the side of the stretcher during transfers (compared with standing at the head and feet), which reduced trunk rotation during lateral transfers (Fig. 17). Friction reducing slide sheets were introduced during site surveys to improve lateral transfers of body bags on Plexiglas. In addition, plywood boards were laid onto floors in the BCP to enhance the maneuverability of stretchers (Fig. 16 & Appendix).

3.3.2.1. Decedent personal property. A key aspect of respectful decedent care during the COVID-19 surge was to develop a system to catalog and actively return the possessions of the departed to family members. Typically, a simple hand-off of possessions occurred from hospital personnel to FDs after identify verification and documentation. However, in cases where decedents were received by the ME (up to 30 personnel to FDs after identify verification and documentation. How typically, a simple hand-off of possessions occurred from hospital healthcare personnel and social workers to contact and actively return personal belongings to family members. Throughout this collaboration, a point of solemn pride among Hospital C personnel was to offer solace to the family by returning possessions. One security officer remarked: “Something that may seem small could be a tremendous deal to the grieving family, that’s their connection to their loved one” - Security Officer Hospital C.

3.3.3. Management and best practices

Among clinical and security personnel at Hospital C, priority was placed on respectful handling of decedents while maintaining safety for all team members involved. This objective was shared by administration and hospital leadership, who secured PPE and equipment and optimized staffing to meet the heavily resource-intensive task of decedent handling. For example, decedent transfers were performed with no less than two team members, increasing as needed for bariatric decedents. In addition, the introduction of friction-reducing slide sheets for use in the BCPs was vital in reducing strain. “No one was hurt [with decedent handling]; we worked as a team and took care of each other” - Security Officer Hospital C.

During the release of an approximately 500 lb. decedent from the BCP, the FD’s gurney collapsed while rolling down the BCP ramp. This caused the ramp to bend. No injuries occurred, and the near-miss presented an opportunity for engineering team members to reinforce ramp design (Fig. 18).

Job rotation among security team members occurred throughout the pandemic. Those who were more acclimated to physical and mental stressors associated with decedent handling volitionally took on those roles. They were supported by colleagues who shifted their responsibilities to maintain overall security operations.

“Long stay” decedents were defined as those who remained in BCPs for greater than 30 days. Fluid would accumulate during this time within the bag, which would shift and alter the center of mass when moving the decedent. This added to the physical strain due to the unpredictability of the load. Awareness and communication of such phenomena helped to reduce injury risk. Tearing of standard body bags did occur throughout

Fig. 16. Hospital C BCP#2 – Plexiglas surface material on wood construction. Floors covered with plywood board.
the decedent handling process at Hospital C. With fluid-filled body bag tears, the spill would require collaboration with lab personnel and engineering to rebuild or sanitize contaminated shelf sections. Measures taken to minimize this risk included placing “long stay” decedents into heavy-duty body bags with handles for improved coupling and to contain fluids.

The hospital offered on-demand mental health counseling and support for team members through the “Code Lavender” program. Team members could call a “lavender” for colleagues, and a mental health counselor would arrive to assess and provide support and intervene as needed. Among decedent handlers, this resource, even if not utilized, represented a de-stigmatization of asking for mental health assistance and collective recognition of the tremendous mental and emotional toll of such work.

3.3.3.1. Hospitals D&E (Liftgate ingress BCP). Hospital D&E exhibited similar routine and mass fatality handling operations as Hospitals A, B & C, including transferring decedents into body bags on the floors, transport to the morgue, identification, then further transport/transfer into the internal morgue or BCP. As such, detailed exposition of these processes will not be repeated. However, at hospital D&E, refrigerated trucks with liftgates were procured as BCPs instead of semi-trailers or standard containers found at Hospitals A and B which used ramps for ingress and egress. Liftgates on these BCPs presented additional ergonomic exposures for decedent handlers. For example, decedent handlers needed to stabilize the stretcher with the decedent during the liftgate operation.

The teams took efforts to find a parking location that considered privacy, proximity from the internal morgue, trip hazards, weather protection, transport surface conditions, and grades (i.e., to minimize forces during uphill and downhill pushing). The liftgate did not level when lowered to the ground (Fig. 19). Hospital D built temporary guardrails as handholds for decedent handlers standing on the liftgate (Fig. 20). In addition, during inclement weather, liftgate platforms became slippery. Inexpensive wheel chocks/blocks were also recommended to secure the stretcher during lifting and lowering as well as non-slip footwear for decedent handlers. Procurement considerations should include liftgate platform dimensions, lift capacity, and internal dimensions of the truck (See Appendix).

4. Discussion

Decedent handling (both routine and during mass fatality events) in the hospital setting involves a broad spectrum of job roles, including nurses, nursing assistants, transporters, EMS personnel, morgue attendants and technicians, pathologists, safety and security personnel, and emergency management. Additionally, postmortem disposition involves supportive actions from other departments, including hospital administration, engineering, social work, patient access, facilities management in coordination with state and local emergency management, and mortuary services. During the COVID-19 surge, other hospital services were in some cases re-deployed and involved directly with decedent handling. Those assuming new roles may be unaccustomed to the physical and mental stressors of decedent handling, potentially increasing their risk for injury and adverse psychological exposure (Notthling et al., 2015).

Analysis of the health system workers’ compensation claims data found a total of 62 claims associated with decedent handling between Jan 2013–Jul 2021. Injuries categorized as sprain/strain or tear comprised 64.5% of all injuries reported and accounted for 95% of total lost workdays and 93% of costs incurred (Table 2). Eighteen injuries were reported in the lower back (29%). In addition, 89% of injuries were reported by four job titles: nursing assistants (22 claims, 35.5%), security personnel (16 claims, 25.8%), patient transporters (12 claims, 19.3%), and registered nurse (5 claims, 8%).

In April 2020, the peak of the “first wave” of COVID-19 in NYC, nine injuries (14.5%) were reported, which was a 200% increase above any other month on record (Fig. 2). Nine percent of claims resulted in lost work days in the twelve months leading to the COVID-19 outbreak in NYC (March 2020). This percentage increased to 33% in the initial twelve months of the pandemic. At a critical time of high volume decedent handling, the loss of team members to injury may acutely increase musculoskeletal handling risks due to decreased personnel available.

Among nurses, high physical demands related to patient handling, including providing care for increased numbers of dependent patients,
staffing levels were variable at times with only a single person per shift, with increased injury risk (Waters T et al., 2009). Throughout the process of on-site consultation, hazard identification, participatory ergonomics, and education, similar risk factors were consistently observed at multiple facilities during the respectful handling of decedents. For example, all decedents could be classified as dependent, mechanical lifts could be used to lift and maneuver decedents using BCP equipment. Inadequate lifting equipment was often unavailable or not practical to use in BCP environments, and staffing levels were variable at times with only a single person performing decedent handling tasks. In addition, repetitive manual lifting and maneuvering of unstable and heavy loads to and from variable heights and surfaces were observed as part of decedent handling.

Advanced planning for future mass fatality events would benefit immensely from a strong foundation in SPHM practices during routine hospital operations. Investment of resources to establish and sustain a culture of safety through consistent use of SPH technologies (vs. manual lifting) is crucial prior to mass fatality events, as adoption during such an event would be partially effective at best. Meta-analysis of 27 articles at 44 sites by Teeple et al., in 2017 showed SPHM programs were highly effective in reducing injury, particularly in settings where patient mobility assistance needs were greatest (i.e. dependent/total assist).

Work processes and environmental design that minimize risk of injury to decedent handlers throughout the span of decedent care should be carefully considered and steps taken to integrate processes during routine handling that could seamlessly transition into mass fatality events. Patient mobility technologies such as lifts and friction reducing aides (air assist devices, slide sheets etc.) as part of a larger SPHM initiatives for patient handling could be used to substantially reduce strain to caregivers during subsequent decedent transfers in transit to and within the morgue or BCP. For example, use of repositioning sheets on medical units (ideally with ceiling lifts) may reduce injury risk during routine patient care tasks such as turning, and boosting. Patient’s expired on repositioning sheets could be lifted onto the transport stretcher. Floor or ceiling based lifts made available in the morgue could then mechanically lift the decedent to storage locations. Such a system would substantially reduce manual handling and make segments of decedent care safe for a single handler. However, aspects of decedent handling which involve rolling and repositioning of patients for post-mortem hygiene, body bag placement, autopsy, as well as for placement of lifting slings would still in many cases require more than a single team member for safety.

During the early surge of COVID-19 in NYC, with the necessity to increase decedent storage capacity using BCPs, the workflow of decedent handling changed, exacerbating existing exposures warranting prompt hazard mitigation measures (Table 3). For example, mass fatality increased volume and rate of decedent handling. BCPs produced constrained work environments and longer transport distances from the fixed morgue to BCPs on potentially uneven surfaces such as sidewalks and ramps. Enhanced PPE created movement and sensory restrictions. Postmortem care in hospitals encompasses a large and diverse workforce. Work environments, training, equipment available, and workload all influence the risk of injury. Planning ahead for location, and design of BCPs can improve safety by minimizing manual lifting, reducing transport distances and save costs by utilizing existing equipment as well as time by building upon a base fluency of hospital team members in use of SPHM technologies. With thoughtful planning, training and engineering controls in place, it is possible to safely perform many aspects of mass fatality decedent transfers with minimal manual lifting. Injury management strategies, best practices, and lessons learned were identified from broader patterns that emerged throughout site observations.

### 4.1. Collaborative interdisciplinary planning

The COVID-19 pandemic in the Spring of 2020 in NYC was an emergent situation without recent precedent. The pandemic produced ongoing mass fatality sustained over months. BCPs were procured emergently, and shelving construction was expedited to meet the rapidly rising capacity demands for decedent storage. As a result, consultation with SPHM and ergonomics specialists did not necessarily occur at the time of initial procurement and construction.

Initial shelving designs in BCPs were optimized for quick construction times (less than 24 h in many cases) and capacity. In many cases, dialogue between frontline decedent handlers and construction personnel occurred, with diligent efforts to accommodate all known issues. However, without additional input from ergonomic and SPHM specialists, neither party could articulate specific ergonomic considerations and optimizations. In all situations, decedent handlers reported that shelves improved the overall experience and reduced strain. This notwithstanding, as with many emergencies, in hindsight, improvements could have been made to reduce strain further.

For example, shelf heights did not match the existing equipment used by decedent handlers at Hospital A, B, C, D, and E. Additional engineering controls such as procurement of specialized lifts and stretchers that would raise and lower to accommodate heights of the highest and...
Table 3
Summary of controls for MSK hazards for decedent handling during mass fatality events in morgues and body collection points.²

| Type of Control | Hazard Mitigation Measures |
|-----------------|---------------------------|
| Engineering Controls | - BCP design  
(APply physical change to the workplace, which eliminates/reduces the hazard on the job/task. See appendix for details.)  
- Shelf height (highest and lowest) must match the capabilities of the hospital stretchers, scissor lifts (incl. crematory lifts) and mortuary cots to eliminate a prolonged/excessive reach and enable working in neutral postures.  
- Three to four tiers increase capacity (requires equipment capable of accommodating)  
- Surface materials such as fiberglass reinforced panels, rigid PVC minimize friction, reduce the risk of body bag tears, and improve disinfection  
- Consider re-design of fixed morgue spaces to reduce manual handling (ceiling lifts, slide-out trays with height adjustable transport surfaces to accommodate)  
- Mechanical lifts  
- Utilize lifts to minimize manual lifting and lowering of decedents to the height of shelves  
- Friction-reducing aides  
- Utilize slide sheets or air assist devices to reduce forces required to transfer decedents between surfaces  
- Heavy-duty body bags with handles  
- Improve coupling to reduce risk of body bag tears  
- Flooring  
- Procure flat floors if the option is available  
- For corrugated floors, lay down boards to improve equipment maneuvering  
- Lighting/electrical  
- Some trucks do not have lighting inside – collaborate with engineering to install temporary lighting  
- Ramps/Lift gate safety  
- Construct temporary guardrails as handholds (Fig. 20)  
- Wheel chocks/blocks to stabilize stretcher while lifting and lowering on liftgate  
- Reinforce ramps as necessary  
- Technique and body mechanics  
- Push whenever possible during transfers  
- Alignment of the body to minimize twisting  
- Push/pull in the sagittal plane (Fig. 17)  
- J-Transfer (Fig. 6)  
- Mortuary cots tilted at declined angles (Fig. 7)  
- Communication  
- Coordinating efforts of team members during handling tasks  
- Verbal confirmation of clearance of handler extremities during decedent transport and operation of stretchers and lift equipment  
- Staffing  
- 2+ personnel for all transfers to limit exertion  
- Procure and optimize accessibility of appropriate personal protective equipment  
- Decedent storage  
- Prioritize storage locations/shelf heights at an optimal height for heaviest decedents to minimize excessive manual lifting  
- Coordination with state and local emergency management and mortuary affairs to facilitate release of decedents  
- Training/Education  
- Ensure team members are trained on equipment and follow processes and procedures  
- Develop and implement safe decedent handling policy  
- Promote safety through utilization of lifts and friction-reducing devices throughout the continuum of patient and decedent handling  
- Advanced planning for mass fatality  
- Consider options for decedent movement and storage with multidisciplinary collaboration which optimizes for worker safety, efficiency, and dignity for decedents and family  
- Surface materials such as fiberglass strengthened panels, rigid PVC minimize friction, reduce the risk of body bag tears, and improve disinfection  
- Heavy-duty body bags with handles  
- Utilize slide sheets or air assist devices to reduce forces required to transfer decedents between surfaces  
- Heavy-duty body bags with handles  
- Reinforce ramps as necessary  
| Administrative and Work Practice Controls | (Institute effective processes or procedures)  
- Technique and body mechanics  
- Push whenever possible during transfers  
- Alignment of the body to minimize twisting  
- Push/pull in the sagittal plane (Fig. 17)  
- J-Transfer (Fig. 6)  
- Mortuary cots tilted at declined angles (Fig. 7)  
- Communication  
- Coordinating efforts of team members during handling tasks  
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- Develop and implement safe decedent handling policy  
- Promote safety through utilization of lifts and friction-reducing devices throughout the continuum of patient and decedent handling  
- Advanced planning for mass fatality  
- Consider options for decedent movement and storage with multidisciplinary collaboration which optimizes for worker safety, efficiency, and dignity for decedents and family  
| Personal Protective Equipment | (Utilize protection to decrease exposure to ergonomics-related risk factors)  
- Thermal gloves  
- To assist with cold conditions while preserving the capability to grasp items easily  
- Non-slip footwear  
- During inclement weather (ice, rain, snow) to reduce slips, trips, and falls  
- Infection prevention  
- Nitrile gloves, isolation gown, N95 respirator, surgical mask, bouffant or scrub cap for hair covering, face shield, or alternative eye protection  

² Adapted from Occupational Safety and Health Administration (OSHA). Overview of Controls for MSD Hazards Guidelines. Retrieved from Ergonomics - Solutions to Control Hazards | Occupational Safety and Health Administration. https://www.osha.gov/ergonomics/control-hazards. Last Accessed: September 16, 2021.

lowest shelves was required. Storage of decedents on the floor could also be avoided if modifiable BCPs are procured with enough time to construct shelving off the ground.

A related pattern observed throughout the hospitals was the difficulty in changing plans and revising construction once initiated due to the quick filling of decedent storage spaces. The unforgiving “one-shot” nature of BCP procurement and design in mass fatality decedent handling underscores the importance of getting it right the first time which is a function of advanced planning (see Appendix).

Heroic effort, agile thinking, and cunning workarounds in the form of modified stretchers, implementation of friction-reducing devices and surface materials, improved administrative controls, and development of new techniques served to mitigate risks (Table 3). However, having the right people in the room during the planning stages is crucial. This would include input from frontline decedent handlers, safety & security, engineering, procurement, administration, SPHM and ergonomic specialists with early and ongoing communications with state and local mortuary affairs and offices of emergency management.

4.2. Friction reduction

Tubular full body length plastic slide sheets (72 inch × 45 inch) were
increased aerosolization of pathogens in confined spaces. These concerns have since been investigated and use of air assist devices is recommended for the handling of bariatric decedents, as needed.

Air assist devices are mats made of low friction materials designed to be positioned and inflated underneath patients to reduce injury risk during repositioning tasks. While these were considered, they were not used for decedent handling in BCPs during the COVID-19 surge for a few reasons. The rapidly moving air underneath the mats raised concerns of increasing aerosolization of pathogens in confined spaces. These devices also require a power supply for the air pump, which were not readily available in some BCPs.

Although air assist devices were not used in this study, their merits have been researched. Like slide sheets, these devices have been found to decrease spinal loads (Fray and Sue, 2015). Another study compared spinal compression and peak hand forces during repositioning tasks of patients at multiple weights (50 kg, 77 kg, 141 kg) using different friction reducing aides (Wiggermann et al., 2021). Air assist devices were found to be the most effective in lowering spine compression and peak hand forces below injury thresholds, especially as patient weight increased. This suggests that these devices may be a valuable tool mitigating risks to decedent handlers and warrants further investigation into best use cases.

Hospitals A and B also used shelf surface materials to further reduce musculoskeletal strain, improve disinfection, and decrease the risk of body bag tears. (See Appendix for details regarding material selection.)

### 4.3. Infection prevention and PPE

Infection prevention was at the forefront of consideration during hospital operations in all departments. PPE was made available, including hospital nitrile gloves, isolation gowns, n95 respirators, surgical masks, bouffant and scrub caps for hair covering, and face shields or alternative eye protection. The entire health system was rapidly fit tested (to ensure fit for a variety of n95 respirators sourced emergently at the start of the pandemic). Instruction on proper use, including donning and doffing, social distancing, and hand hygiene per Centers for Disease Control and Prevention guidelines, was strictly adhered to.

Routine sanitization of the fixed morgue and BCP surfaces was conducted using disinfectant wipes throughout mass fatality decedent handling operations. Additionally, Hospital B used ultraviolet light disinfection. At Hospital C, decedent personal belongings were sanitized and double bagged before hand-off to FDs or the patient’s family.

Bodybag tears and spills may be a substantial vector of infection. Heavy-duty body bags with handles and secondary envelopment were strategies to reduce the risk of body bag tears, especially for “long stay” decedents. In addition, hospital B utilized patient repositioning sheets designed for use with lifts throughout the decedent handling workflow. The repositioning sheets had straps that could be cinched around body bags to provide additional handholds to minimize tearing while handling (in addition to their normal use with lift equipment).

Additional considerations for PPE included providing work gloves, which personnel at hospital C wore over nitrile hospital gloves for temperature and laceration protection. Expanded morgue capacity was almost universally external to the hospital. As a result, protection from the weather is a necessary consideration during mass fatality events.

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4 These concerns have since been investigated and use of air assist devices is approved appropriate with proper PPE.

### 4.4. Staffing recommendations

Decedent handling during a routine, and especially during mass fatality events, is physically demanding. The consensus among hospital leadership, safety personnel, and decedent handlers were to have no less than two personnel for decedent handling tasks. All hospitals involved agreed, and site leadership secured staffing to provide adequate coverage throughout the COVID-19 surge. Additional personnel were recommended for the handling of bariatric decedents, as needed.

### 4.5. Psychological and mental health support

A literature review of military personnel involved with handling human remains reported more symptoms of psychological stress and post-traumatic stress disorder when compared with those not involved in mortuary operations (Peterson et al., 2002). These authors found a dose-response relationship between exposure and psychological distress. The sustained and elevated volume decedent handling over many months during the early stages of COVID-19 mass fatality in NYS represented a prolonged, cumulative psychological exposure for decedent handlers.

Psychological support for decedent handlers is necessary to maintain wellness, morale and operational effectiveness. Best practices in facilities throughout this study included availability of psychological services through mental health professionals, routine rounding, mental health crisis intervention, and open recognition of the psychological stressors faced by decedent handlers and healthcare workers by peers and leadership. Community support, in the form of meals and messages of gratitude, as well as informal check-ins from other departments, were mentioned by decedent handlers as helpful towards their psychological well-being and overall feeling of being supported.

Additional coping strategies found among decedent handlers, as outlined by Peterson et al. (2002), included:

- Pairing inexperienced individuals with more experienced individuals.
- Compartmentalizing and focusing on the work while limiting thoughts and emotions.
- Remembering the importance and meaning of the task to the families of the deceased.
- Taking opportunities to have humorous exchanges among colleagues.

### 4.6. Strengths and limitations

Observations and experiences recorded by the authors represented patterns of decedent handling workflow and exposures at five hospital facilities within the Northwell Health system may not be representative of what other regions and states may have experienced. Variability in the morgue and BCP design, equipment options, training and personnel availability can substantially change exposures to decedent handlers. The BCPs described in this case series were all procured by the hospitals with system emergency management support. Construction of shelving was permitted. However, this was not the case at many hospitals where BCPs were provided through the Office of the Chief Medical Examiner (OCME) or by state and federal emergency management entities.

This case series focused on decedent handling at the morgue and BCPs which accounted for 33 (53.2%) cases of injuries reported. Decedent handling on medical units and during transit to the morgue which includes tasks such as placement of the decedent into the body bag, transferring from the hospital bed to the cadaver carrier, and transporting the decedent to the morgue accounted for 29 (46.7%) of reported injuries. This is an area of that requires further investigation to develop strategies to mitigate risks.

The participatory ergonomics and risk management strategies described were implemented after the initial surge in a mass fatality.
Exposure controls described here primarily represent efforts to optimize existing construction and work practices. Unmitigated risks following site investigations included the volume of decedent handling, as well as the transport distances from the morgue to the BCPs.

Strategies for risk reduction during lifts to and from the floor are not mentioned in this case series. This represents the only option for storage in BCPs where construction is not permitted. Floor transfers require considerable musculoskeletal exertion, and safe and respectful decedent handling to and from the floor requires further investigation.

Qualitative data regarding decedent handler experiences were composed from memory, based on interaction with decedent handlers, or constructed during follow-up conversations 18 months after the initial March 2020 surge. Temporality from past events may have affected decedent handlers’ narratives. Psychosocial exposures were identified, however not explored in-depth, warranting further study. Nevertheless, this case series offers insights into the experience of decedent handlers during the height of the COVID-19 in one of the initial hardest-hit regions in the U.S.

5. Conclusions

Respectful handling and dignified processing of the departed are paramount for healing, closure, community morale, and societal functioning in routine times, as well as during mass fatality events. Among decedent handlers involved in this case series, this sentiment and duty to treat the departed with dignity was evident through actions. The musculoskeletal and psychological exposures faced by decedent handlers during the early COVID-19 pandemic in NYC may have elements in common with non-pandemic-related mass fatality events in the hospital setting. Musculoskeletal exposures associated with decedent handling are a microcosm of similar exposures during patient handling tasks which contribute to high rates of musculoskeletal injury among healthcare workers (Bureau of Labor Statistics, 2014). Further study of musculoskeletal exposures on medical units and during transit is necessary to improve decedent handler safety throughout the continuum of decedent care, including recommendations for morgue & BCP design, SPHM equipment and aides, body handling techniques and training, staffing, work rotation policy, psychological interventions, and collaborative planning for current and future mass fatality events.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

The authors would like to thank the following colleagues at Northwell Health for their expertise and contributions to the development of best practices for safety discussed in this manuscript: Eric Becker, Devon Betts, Kris Brandt, Yaritza Cano, Erin DiCandia, Jonathan Edwards, Jeffrey Fugelsang, Paul Furbeck, Nora Goldberg, William Hayes, Joseph Hein, Richard Hicks, Sydekie Kalokoh, Lisa Kilfeather, Dennis Kramer, Alfonso LaFemina, Dylan Machado, Richard McCusker, Joshua Melendez, Regina Moller, Edward Morgan, Leonard Mormino, Ruth Neuman, Anthony Rambazis, Edward Ramos, Brian Schieferstein, & Sean Smith.

The authors would also like to thank PATRAN® for their donation of slide sheets utilized throughout hospitals involved in the case series for decedent handling.

Appendix

BCP Procurement & Design Considerations

Regarding BCP procurement (if the choice exists), the vessel’s dimensions are crucially important to consider, as they will influence storage design, capacity for storage, ergonomics of decedent handlers, and overall safety and efficiency.

Early procurement of BCPs is essential, allowing greater time for communication between mortuary staff, engineers, safety personnel, procurement, and planning for construction.

An optimal location for the BCP considers privacy, security, ingress and egress options, protection from the weather, proximity from the internal morgue, reduced slip/trip hazards during transport, and level terrain.

Refrigerated Container and Trailers

In the United States, the Department of Transportation set a maximum width of 102in/8.5ft/2.6m for trailers (108in/9 ft in Hawaii). The length of trailers in the United States is typically 48ft/14.6m to 53 ft/16.2m. Containers are a standard width of 8ft/2.44m based on ISO International Standard 668 for freight and shipping containers.

Internal width varies based on insulation; however, generally, there is at least 7.25 ft (87in/2.2m) of width internally for both refrigerated containers and trailers.

According to the National Aeronautics and Space Administration Anthropometry and Biomechanics section, a shelf width of 23 inches can accommodate male decedents of up to 95th percentile bi-deltoid breadth (20.9in).

Commonly used stretchers range between 23 inches (EMS stretcher, Fig. 10) to 31 inches (hospital transport stretcher). Stretcher width dictates positioning of decedent handlers either on the side of the stretcher or at the head and foot (Figs. 21 and 22). Use of stretchers which allow standing to the side is recommended as it allows for pushing and pulling in the sagittal plane, reducing rotation of the trunk.

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[3] U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations. Federal Size Regulations for Commercial Motor Vehicles. https://ops.fhwa.dot.gov/freight/publications/size_regi_final_rpt/ [Last accessed, September 16, 2021].

[4] International Standard (ISO). ISO-668. 6th Ed. 2013-08-01. Series 1 freight containers – Classifications, dimensions, and ratings. https://web.archive.org/web/20190331092550/https://www.sis.se/api/document/preview/916460/ [Last accessed, September 16, 2021].

[5] National Aeronautics and Space Administration (NASA). Anthropometry and Biomechanics. https://msm.jsc.nasa.gov/sections/section03.htm. [Last accessed, September 16, 2021].
Refrigerated Truck with Liftgate

Liftgate platform dimensions and lift capacity are not standardized and require careful consideration for weight capacity, depth, and width during use for decedent transport.

Weight capacity must accommodate the anticipated working load for decedent transfers. A sample calculation may include the weight of a stretcher (265–355 lb/120-161 kg)$^8$ + two decedent handlers (400 lb/181 kg)$^9$ + weight of decedent (200–650 lb/91-295 kg). This example requires a liftgate capacity of between 865–1405 lb/392–637 kg.

A sample calculation for liftgate dimensions would include a hospital stretcher 36 in/91.4 cm width$^{10}$ + 17 in/43.2 cm for decedent handlers to

$^8$ Hill-Rom p8000 procedural stretcher low and high weight ranges (not including mattress).
$^9$ Average body weight for men in U.S. 199.8 lb (https://www.cdc.gov/nchs/fastats/body-measurements.htm). [Last accessed, September 16, 2021].
$^{10}$ Hill-Rom p8000 procedural stretcher width with side rails up (https://www.hill-rom.com/globalassets/website-documentation/english-websites-us-int/stretchers—int/procedural—int/procedural-stretcher-tech-spec-5en145302-02.pdf) [Last accessed, September 16, 2021].
Stretcher length is 83 in/210.8 cm. Liftgate dimensions of at least 85 in/215.9 cm x 53 in/134.6 cm is recommended (Fig. 23).

Shelf Construction Considerations

BCPs discussed in this article were leased, and shelving construction was permitted as long as alterations were not permanent and did not damage the interior.

Material Choice

The teams at Hospital A, C, D, & E utilized wooden shelves. These shelves could be constructed quickly and at a relatively low cost. Wood is not ideal as a shelf surface material, however, due to abrasion and friction against body bags. The weight capacity of shelves needs to be carefully considered, mainly when multiple tiers of shelves are used (consult with engineering professionals). Wood may also be porous and more difficult to disinfect and clean. Lining shelves with friction-reducing non-porous materials improves disinfection and reduces force required during transfers. Recommended materials described in the case series include fiberglass reinforced panels (Hospital A) and rigid PVC board (Hospital B).

High-strength metal alloy materials (as seen in Hospital B) can support the load with less bulk in the chassis. This can reduce the profile of shelf frames and increase space for decedents, trays, and equipment. Metal alloys, such as stainless steel, also reduce friction during transfers.

Shelf Design

Bilateral multi-tier shelving with a center walkway was the selected design of most hospitals featured in this case series. (See Hospital A case series for more information behind the rationale and usage of a unilateral design.) Multiple factors are essential to consider when designing multi-tier shelving. Increasing the number of tiers will expand storage capacity at the expense of reduced shelves at optimal height. Maximal and minimal heights of stretchers and lift equipment should be considered before constructing multi-tier shelving. If existing equipment does not accommodate new construction (commonly the case with more than three or more tiers) it is essential to procure additional equipment to reduce manual lifting while raising and lowering decedents to match shelf tiers.

Shelf construction will vary based on materials used and intended number of tiers. General width (Fig. 21) and height dimensions (Fig. 24) to maximize usability are important to consider prior to construction or procurement of racks. Recommended distances between shelves are between 13 in-18 in/33.5 cm–45.7 cm. Recommended shelf length is 72 in/182.8 cm. Distances between shelves may vary based on anthropometrics of decedent population. The National Institute for Occupational Safety and Health recommends optimal surface heights for work should range from 28 in to 35 in, or 4 in to 6 in below elbow height (Cohen et al., 1997).

Fig. 23. Recommended liftgate dimensions.
Fig. 24. Diagram of shelving dimensions and considerations. Tier 2 height is optimal for bariatric decedents and slightly larger. Tier 1, 3 and 4 at sub-optimal heights and intended for decedents of average or below average weight.

Additional BCP Considerations

Floors
Refrigerated BCPs may have grooved (corrugated) (Figs. 6, 13 and 16) or flat floors (Fig. 25). If possible, procure BCPs that have flat floor designs for improved maneuverability of wheeled stretchers. Laying down plywood flooring (or similar material) over grooved floors is recommended to improve the maneuverability of stretchers and equipment.

Fig. 25. Hospital E refrigerated truck BCP with flat floor.

Lighting
Procure BCPs with integrated lighting. If lighting is not integrated, consult with engineering services to wire electrical and lighting solutions.

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14 Actual lift ranges of equipment and handler anthropometrics are variable and require individualized consideration for shelf construction.
15 Supine male reference image credit dimensions.com.
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