RESEARCH

1918 Influenza Outcomes among Institutionalized Norwegian Populations: Implications for Disability-Inclusive Pandemic Preparedness

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People with disabilities are often at increased risk during infectious disease pandemics, due to complex biological and social factors. Synergistic biological interactions can lead to severe complications or reduced vaccine efficacy, while people with disabilities also tend to have lower access to health care, higher rates of poverty, might be institutionalized, and are frequently excluded from preparedness planning and crisis responses. Further, there are limited data from historical epidemics to inform public health efforts that address disability concerns. We provide novel evidence for disability-related disparities in influenza outcomes using data from Norwegian psychiatric hospitals and schools for children with disabilities during the 1918 influenza pandemic. Both students and patients suffered higher mortality compared to staff members. Recognition of differential risk factors for people with disabilities is essential for the development of equitable and effective pandemic preparedness policies.

Keywords: disability; influenza; 1918 influenza pandemic; pandemic preparedness; Norway

Approximately 15% of the global population lives with a significant disability, including physical, sensory, intellectual, or mental health conditions (WHO 2011; Groce 2018). As the 'largest minority' (UN 2019), people with disabilities comprise a substantial population that might be at increased risk during influenza pandemics, especially when considering intersections with other potential risk factors such as gender or socioeconomic status. Previous work has highlighted public health concerns related to, for example, institutionalized populations and accessible communication (Campbell et al. 2009). Yet, few studies have looked at the actual experiences of people with disabilities during previous pandemics, while disability remains under-addressed in pandemic preparedness plans.

To better understand why and when people with disabilities may have differential exposure, susceptibility, and/or access to care and thus differential outcomes from influenza versus non-disabled populations, researchers must fully appreciate the complex links between social conditions and biological variables. For example, the fact that people with disabilities face preventable health conditions can go unrecognized, because disability and good health are often viewed as contradictory (Krahn, Walker & Correa-De-Araujo 2015; Wisdom et al. 2010). Further, attitudes such as what counts as or what causes disability or whether disability communities are considered subcultures vary across space and time, necessitating both historical and ethnographic studies (Ginsburg & Rapp 2013; Reid-Cunningham 2009); the same is true for variation in the understanding of infectious disease transmission and treatment. Historical data also contribute to the evidence base needed to develop more inclusive and equitable preparedness policies and interventions. In this paper, we first establish a broader context for disability-influenza concerns by discussing recent work on interactions between these conditions, as well as the status of national-level pandemic preparedness policies with regards to disability. We then illustrate disparities using records of people with disabilities residing in Norwegian institutions during the 1918 influenza pandemic, and conclude with recommendations for current preparedness policies.

Relationships between Disability and Influenza
Different models conceptualize disability from a medical or social stance (Groce & Kett 2013), while others (e.g. the International Classification of Functioning, Disability and Health [WHO 2018]) integrate personal, biological, social, and environmental factors. Similarly, the relationships between disability and influenza can be studied from an epidemiological perspective of synergistic interactions, as well as by focusing on social factors such as discrimination or health care access. Biocultural approaches are thus particularly appropriate for studying relationships between disability and influenza.

The potential for disability as an outcome of influenza has long been recognized, with some hypothesized connections more strongly demonstrated than others (Manjunatha et al. 2011; Maurizi 1985; Menninger 1919, 1926; Rorie 1901). For example, as seen in studies following the SARS epidemic, mental health consequences might include post-traumatic stress disorder or effects of social isolation among those who are quarantined or stigmatized as a result of infection (Douglas et al. 2009). Also, older individuals are more likely to develop a physical disability or experience a decline in activities of daily living after a bout of flu; mouse models indicate inflammation, muscle atrophy and expression of genes related to muscle mass regulation are involved (Bartley et al. 2016).

The role of disability as a risk factor for influenza illness or complications is equally important. For example, neurologic and neuromuscular conditions are known risk factors for influenza. Children with these conditions are disproportionately represented among hospitalizations, severe complications, and deaths (Havers et al. 2014). A third of pediatric influenza-associated deaths in the United States from 2004 to 2012 were among children with histories of these conditions (Wong et al. 2013). During the 2009 H1N1 pandemic, 343 child deaths were reported to the Centers for Disease Control and Prevention (CDC). Of the 336 cases with information on underlying health, 43% had neurologic conditions, including intellectual disabilities, cerebral palsy, and epilepsy (Blanton et al. 2012). Suggested mechanisms for this increased vulnerability include diminished respiratory muscle strength or reduced pulmonary function due to impaired mobility or related structural conditions like scoliosis (Havers et al. 2014; CDC 2012).

Researchers also have looked at the relationship between Down syndrome and respiratory diseases. In a cohort study of causes of death among adults with intellectual disabilities in England, Hosking et al. (2016) found that respiratory diseases were the most common cause of death among adults with Down syndrome, accounting for just over 20% of the sample. If deaths with respiratory disease as a secondary cause were included, the percentage increased to approximately 42%. Perez-Padilla et al. (2010) found increased likelihood of hospitalization and death for influenza patients with Down syndrome during the 2009 H1N1 pandemic in Mexico. Down syndrome might put individuals at higher risk because of correlated factors like congenital heart disease or cardiac defects, obesity or excess weight, lower immune system response, and diabetes (Perez-Padilla et al. 2010; Havers et al. 2014).

People with spinal cord injuries also are at increased risk from respiratory diseases and related complications. Effects of reduced mobility, such as weakened respiratory muscles, bronchoconstriction, and a weak cough, contribute to this risk (Goldstein, Weaver & Hammond 2005; Nygren-Bonnier et al. 2011). Chronic spinal cord injury also depresses immune system function (Zha et al. 2014; Bracchi-Ricard et al. 2016).

Influenza vaccination is currently the most important prevention and control strategy, but different types of disability might lead to reduced vaccine efficacy. For example, Hara et al. (2016) found that vaccine efficacy was low among a sample of Japanese individuals with severe motor and intellectual disabilities; they concluded that results were due in part to diminished immunogenicity in the population. Similarly, Otsuka and colleagues found that persons with multiple severe disabilities who were hospitalized in Japan had low responses to flu vaccination (Otsuka et al. 2006; Otsuka et al. 2007). Further, physical, financial, and social barriers might prevent effective coverage. Research on vaccine access and uptake among people with disabilities has produced mixed results. Several studies have found similar or higher vaccination rates compared to the general population or specific demographic counterparts (Bocquier et al. 2017; Parish & Saville 2006; Iezzoni et al. 2000); others show lower or suboptimal rates (Lorenz et al. 2013; Henderson et al. 2007). The severity of disability often plays a role; for example, Yen et al. (2012) found that individuals with moderate or severe disability were more likely to have had a vaccine than those with mild disabilities, while opposite results (mild and moderate more likely than severe) were found by Diab and Johnston (2004). Even with mixed findings on the *relative* rate of vaccination among people with disabilities, the *absolute* coverage is still concerning, as nearly two-thirds do not receive seasonal influenza vaccinations (Campbell et al. 2009).

Social issues related to disability and influenza extend beyond vaccination. In terms of demographics, disability is more prevalent in populations that also tend to be disproportionately impacted by epidemics and other health burdens. The majority of people with disabilities live in developing or low- to middle-income countries (Groce & Kett 2013; UN 2019). Rates also vary within populations; for example, in the United States, disabilities are more prevalent among females and African American and Native American populations (Campbell et al. 2009; Wisdom et al. 2010). The disabled population is expected to grow due to improvements in medical care that lead to the survival of individuals who otherwise might have died, as well as to the aging population (Groce 2018; Iezzoni 2009). Poorer people are at greater risk of becoming disabled, and people with disabilities typically have less access to education and employment, and so are more likely to live below poverty levels, face difficulties finding affordable housing, and suffer from undernutrition. (Iezzoni 2009; Groce 2018; Campbell et al. 2009; Groce and Kett 2013). Despite development and public health efforts, the socioeconomic gap between disabled and non-disabled populations is growing in many countries (Groce 2018). These disparities can affect underlying health, the ability to fight off infection, and access to or use of preventive and therapeutic health services. Because disability is still often viewed from a medical perspective as requiring specialist services, affected populations may be inappropriately excluded from more general health education and intervention programs (Groce & Kett 2013). Similarly, public health measures often focus on biomedical and epidemiological methods and fail to recognize the web of social factors that lead to disparities (Atlani-Duault & Kendall 2009; Singer 2009).

Disability and Pandemic Preparedness

Due to discrimination and other social factors, people with disabilities often lack political power and are overlooked by public health efforts (Groce 2018). Mamelund (2017) and Uscher-Pines et al. (2007) have critiqued organizations for the focus on medically-defined risk factors at the expense of socially vulnerable populations in pandemic preparedness plans, while Kayman and Ablorh-Odjidja (2006) and O'Sullivan and Bourgoin (2010) argued for the need to include social justice perspectives in preparedness planning. The European Disability Strategy 2010–2020 recognizes that people with disabilities are entitled to health services during emergencies, while the Standard Rules on the Equalization of Opportunities for Persons with Disabilities state that disability concerns should be incorporated into general rather than disability-specific policies (European Commission 2010; UN 1994). Nonetheless, people with disabilities are rarely explicitly listed as priority groups for vaccination, and non-pharmaceutical issues are under-addressed as well (Campbell et al. 2009; Perez-Padilla et al. 2010; Groce and Kett 2013). Indeed, some plans for the allocation of potentially limited health care services exclude people with disabilities, even when the underlying condition is unlikely to reduce the chance of a successful outcome (Hensel & Wolf 2011).

We have reviewed 12 national pandemic preparedness plans or summaries available in English, as well as Norway's plan, all posted online (CDC 2017; ECDC 2018). Only five of these plans – developed by France, Ireland, Luxembourg, Norway and the United States – explicitly mention disability. However, in these five plans, people with disabilities are typically mentioned only as one example in a list of at-risk or vulnerable populations, despite having different rights and facing different barriers than other such groups. Other, rare mentions focus on biomedical concerns, namely vaccination recommendations or contraindications for specific disabilities. All 12 reviewed plans contained broader but potentially applicable text, falling into three general categories: discussion of priority vaccination groups including people with chronic medical conditions, ethical frameworks for allocating limited resources, and public health communication strategies.

The lack of detailed and specific consideration of disability-related concerns in these plans is likely due to a number of factors, including relatively limited discussion of social risk variables in general, as well as discrimination and the exclusion of people with disabilities from policy development. Another contributing factor might be the lack of data on outcomes among people with disabilities during historical epidemics (Campbell et al. 2009). Aside from the 2009 H1N1 pandemic, there are no studies, to our knowledge, focusing on disability as a risk factor during historical flu pandemics. The following analyses thus provide important contributions to the study of inequalities during pandemics among populations who are both biologically and socially at risk.

Differential Outcomes at Norwegian Institutions in 1918

This study draws on Norwegian data from the 1918 influenza pandemic, which killed an estimated 50–100 million people worldwide (Johnson and Mueller 2002). Our data sources include annual reports from 1918–1919 for several schools for children with disabilities, system-level reports for both schools and psychiatric hospitals, and a published report by Olav Hanssen (1923), who collected information on the 1918 pandemic for the city of Bergen and other areas of southwestern Norway from, among other sources, psychiatric hospitals. The system-level reports are publicly available online at Statistics Norway (https://www.ssb.no/), while the institutional-level annual reports are held at the National Archives of Norway in Oslo. Permission to access restricted files was obtained via correspondence from the Director General of the National Archives in September 2019.

There were nine schools for children with disabilities in the school system in 1918, although only three of the individual reports have been found at the National Archives of Norway. Schools were specified for blind, deaf, and intellectually disabled children. The majority of students and staff resided in the boarding schools, although many schools also had a smaller proportion of external students who lived with family or were placed in other residences nearby.

Annual reports included brief sections on the health conditions at the schools. For example, Holmestrand School for the Deaf reported that all 46 children were affected by the flu, and there were two deaths. No cases of illness were reported among the employees, although it was not uncommon for these reports to also mention changes in the staff (Holmestrand School for the Deaf 1920). Incidentally, records from a tuberculosis epidemic beginning in 1933 showed a similar bias, where 35% of the students were affected and six were sent to a sanatorium, while no staff members showed any lung changes consistent with the disease (Holmestrand School for the Deaf 1935). At Trondheim School for the Deaf, one girl out of 98 students died during the 1918 influenza pandemic. No further information was available in this report, because the school doctor had died earlier in the year from an unstated cause and so was unable to write the annual report (The Public School for the Deaf in Trondheim 1919). Finally, the Thorshaug [Torshov] School for intellectually disabled children, reported that the flu 'ravaged badly' in the winter, affecting almost all students and most of the staff. There were five student deaths, three of them within three days in mid-November and two in the later spring wave. The head cook also died in November (Thorshaug [Torshov] Public School for the Intellectually Disabled 1919).

These reports are suggestive of the burden of disease among disabled students compared to the staff living in virtually identical conditions. However, the reports are also anecdotal and thus limited. Results from the psychiatric hospital data build on these findings, though. In Norway, the asylum system was heavily developed in the early 20th century, spurred in part by changing views on causes and treatments for psychiatric conditions, and social changes like urbanization

and the development of the welfare state. There were 21 institutions in Norway in 1918 (Kringlen 2004; Søndenaa, Gudde & Thomassen 2018). The Mental Illness or Insanity Act (*sinnsjukeloven*) of 1848 was the first to treat people with mental illness as separate from the poor and established requirements for official asylums. These requirements included segregation of patients by gender and diagnosis. However, references in annual reports to daily activities and special celebrations suggest that, in practice, this segregation was not strict and social mixing did occur. After the act's passage, newer institutions tended to be state-owned rather than private. Most were relatively distant from urban areas. Work was considered therapeutic, and treatments included baths and isolation (Medical Director 1921; Vold n.d.; Jordåen n.d.).

Hanssen's report lists the number of cases and deaths for both patients and staff by age in 10-year groups from 10–19 through 80–89, by sex, and for deaths only, by wave of the pandemic for seven psychiatric institutions. Cases and deaths are not separated out by mental health diagnosis. However, the annual system-level reports list conditions including melancholia, mania, dementia, paranoia, and idiocy. In the 1918 report, the most common reason for admission and treatment across all of the institutions was dementia (3203 or 60.9%), followed by melancholia (446 or 8.5%) (Medical Director 1921). Of course, terms similar to those used today might not refer to the same condition, while other historical reasons for institutionalization might no longer be considered illnesses today. In an analysis of data from forensic asylums in Norway at approximately the same time, Dahl (2017) observed that diagnosis played less of a role in daily concerns than patient behavior and so alone did not determine care decisions.

Several adjustments to the original data were required prior to analyses. First, because no staff members were older than 69 years old, we removed patients in older categories from the sample. There were 49 patients in the 70–79 year age group (4 cases, 0 deaths) and 5 patients aged 80–89 (0 cases). Second, for Neevengaarden, more cases of illness were reported than there were patients at risk for four of the age-sex groups; there were no discrepancies for the staff population. In order to match the recorded cases, we increased the number of patients in different groups by about 3% (from 36 to 37 females aged 50–59) up to 25% (from 4 to 5 males aged 10–20). Third, at Rosenberg, the report lists one case of illness but five deaths among male patients aged 20–29 years. We treated this as a transposition error, i.e. five cases and one death, yet analyses counting all five as deaths did not change significant results. Fourth, the data reported for Eg lists cases and deaths but not the number of people who escaped infection in each group. The text includes the total number of staff, not separated by sex, and the total number of male and female patients. To allocate the staff population at risk, we calculated the average sex ratio and the average proportion of males and females in each age group at the other institutions in our sample and distributed the total for Eg accordingly, rounding to whole numbers. A similar process was used to allocate patients at risk to specific age groups, except the female age distribution was based on all other institutions except Rosenberg, which only had male patients. The process resulted in only one expected female patient aged 10–19 while the recorded data showed two deaths in this group, so the population at risk was increased. To compensate, one female patient aged 70–79 was removed from the total population. Finally, at Opdal, one female staff member aged 50–59 was not counted as either having escaped illness or becoming sick. We retained this individual in the population at risk and did not count her as a case.

Our analyses explore whether patients were at increased risk for influenza-like illness or death during the 1918 pandemic compared to the staff, who we assume did not have disabilities or at least did not have mental health impairments that were recognized or severe enough to prevent employment at the institutions. To analyze morbidity differences, we transformed the aggregate-level data to individual-level data using dummy variables. We then used logistic regression models to determine whether patient status predicts illness during the pandemic, with controls for age, sex, and institution. Because only two deaths occurred among the staff, logistic regression models are not reliable for mortality. Instead, we evaluated whether there were significant associations between patient status and case fatality using chi-square or, with smaller sample sizes, Fisher's exact tests.

Results
Table 1 summarizes the sample. On average, the employees are 11 years younger than the patients. There are slightly more male than female patients, while this bias is reversed for the staff. The two largest institutions, Eg and Neevengaarden, account for nearly half of both samples. Overall, there are approximately four patients per employee. According to the 1918 annual report, most of the institutions were overcrowded relative to their authorized number of beds. The institutions in our sample, except Neevengaarden, ranged from 7% (Møllendal) to 25% (Opdal) over capacity. At the time of the report, Neevengaarden was under capacity, but it was noted that usually too many beds were authorized in the first place (Medical Director 1921).

Morbidity (percent of cases in the sample) is more than twice as high for the employees than for the patients (**Table 2**). Considering demographic subgroups, there is higher employee morbidity for all ages, both sexes, and at every institution except Rosenberg. There were only two deaths among the staff, for a case fatality rate (CFR) of 1.1%, compared to 30 deaths or 9.8% CFR for the patients. The majority of the patient deaths were among those aged 20–49 years, while they were fairly evenly split between male and female patients. Nearly half of the patient deaths occurred at Rosenberg. The CFR is 6.6% overall, three times higher than the 2.2% recorded for the fall wave in the nearby region of Bergen in Norway (Mamelund, Haneberg & Mjaaland 2016).

Table 1: Sample Details.

Covariates	Patients (%)	Employees (%)
N	1282	337
Age (years)		
10–19	26 (2.0)	31 (9.2)
20–29	210 (16.4)	160 (47.5)
30–39	370 (28.9)	77 (22.8)
40–49	298 (23.2)	41 (12.2)
50–59	229 (17.9)	21 (6.2)
60–69	149 (11.6)	7 (2.1)
Sex		
Males	692 (54.0)	150 (44.5)
Females	590 (46.0)	187 (55.5)
Institution		
Eg	288 (22.5)	80 (23.7)
Neevengaarden	279 (21.8)	84 (24.9)
Dale	207 (16.1)	53 (15.7)
Valen	192 (15.0)	47 (14.0)
Opdal	137 (10.7)	36 (10.7)
Rosenberg	95 (7.4)	20 (5.9)
Møllendal	84 (6.6)	17 (5.0)

Table 2: Morbidity and case fatality among patients and employees.

	Patients (N = 1282)		Employees (N = 337)	
	Morbidity (%)	Case Fatality (%)	Morbidity (%)	Case Fatality (%)
Total	305 (23.8)	30 (9.8)	180 (53.4)	2 (1.1)
Age (years)				
10–19	10 (38.5)	0 (0)	23 (74.2)	0 (0)
20–29	75 (35.7)	9 (12.0)	103 (64.4)	1 (1.0)
30–39	100 (27.0)	12 (12.0)	35 (45.5)	1 (2.9)
40–49	56 (18.8)	6 (10.7)	12 (29.3)	0 (0)
50–59	48 (21.0)	1 (2.1)	6 (28.6)	0 (0)
60–69	16 (10.7)	2 (12.5)	1 (14.3)	0 (0)
Sex				
Males	166 (24.0)	17 (10.2)	70 (46.7)	1 (1.4)
Females	139 (23.6)	13 (9.4)	110 (58.8)	1 (0.9)
Institution				
Eg	48 (16.7)	1 (2.1)	48 (60.0)	0 (0)
Neevengaarden	78 (28.0)	1 (1.3)	36 (42.9)	1 (2.8)
Dale	30 (14.5)	2 (6.7)	35 (66.0)	0 (0)
Valen	66 (34.4)	7 (10.6)	25 (53.2)	0 (0)
Opdal	19 (13.9)	1 (5.3)	23 (63.9)	0 (0)
Rosenberg	45 (47.4)	12 (26.7)	3 (15.0)	0 (0)
Møllendal	19 (22.6)	6 (31.6)	10 (58.8)	1 (10.0)

The first known case was reported for six of the institutions, and for all of these, it was a staff member. For example, a kitchen girl brought the disease to Valen after visiting home, where her brother was sick. The first cases at Opdal were in the director's family, and he later fell ill himself after treating several workers at a nearby power plant barracks. Such instances likely supported decisions to use preventive measures such as restricting visits and travel to the surrounding communities. Other reported strategies included isolation and disinfection. The report from Opdal observed that several minor cases may have not kept to bed; this behavior might have contributed to disease spread (Hanssen 1923; Medical Director 1921).

Most of the institutions escaped the summer wave in 1918 and only had cases during the fall wave, even though surrounding communities typically experienced both. A nurse at Dale fell ill on December 28 and except for two other nurses, no further cases appeared for two weeks after that. At Valen, the first case was in early to mid-October, while the last occurred November 2. The reports from this institution noted that all deaths were from pneumonia and were among the 'dullest and physically most frail' patients. All cases at Opdal occurred in mid-October. The majority of deaths at Rosenberg and all the deaths at Møllendal were attributed to secondary pneumonia. At Møllendal, the outbreak began on November 6, with the first cases among patients occurring November 20. The epidemic ended approximately December 25, although some individuals complained of neuralgia for weeks after (Hanssen 1923; Medical Director 1921).

Only Neevengaarden and Eg had cases recorded for both the first and second waves. At Neevengaarden, the first case occurred on July 2, with the first patients becoming ill on July 10 and the outbreak ending on July 22. A few cases, described as questionable, occurred in September/October. The epidemic primarily affected one female ward and two male wards. At Eg, only males were affected in July, while mostly females were affected during the fall wave (Hanssen 1923).

Table 3 reports the results of the logistic regression models for morbidity. Model 1, considering only patient/employee status, shows that patients had significantly lower morbidity than employees. When controlling for age (Model 2), this result holds; however, the odds ratio increases (i.e. the difference between morbidity outcomes is smaller), likely because employees are younger on average and so more represented in the 20–29 age group, which experienced substantial morbidity. Morbidity generally decreased with age. Adding sex does not substantially affect the results between patients and staff (Model 3). Finally, Model 4 indicates that, when controlling for all covariates, morbidity is still about 61% lower among patients. The age patterns seen earlier are retained, and females have significantly higher morbidity than males. There is significantly higher morbidity at Rosenberg, as well as significantly lower morbidity at Dale and Opdal, compared to the reference of Neevengaarden. Model fit estimates show improvement going from model 1 to model 4.

Table 4 presents results for tests of association between patient status and case fatality. For each sex, as well as for both sexes combined, patients had significantly higher case fatality than would be expected if there were no association. Due to the few number of employee deaths, further subdividing groups by demographic variables produces increasingly less reliable results. Nonetheless, when different age groups are considered, significant relationships are found for the 20–29 year age group for females only and for both sexes combined (not shown). Employee deaths only occurred at two of the institutions. When evaluating these independently, there is no significant association between patient status and case fatality at Neevengaarden, while at Møllendal, significant case fatality differences are only seen for females in all age groups combined (Fisher's exact, p = 0.044).

Discussion

Overall, morbidity was lower for patients than for staff, while case fatality was higher. Morbidity decreased with age and was highest in the 10–19 and 20–29 year age groups. Higher case fatality among patients was seen for the sample as a whole, for males and females, and for all patients aged 20–29 and female patients aged 20–29. These results are generally consistent with previous work on the 1918 flu. For example, the pandemic had a W-shaped age distribution where prime-aged adults suffered higher mortality than they typically do during seasonal epidemics (Crosby 2003).

Patient disparities in pandemic outcomes can be explained by differences in exposure, susceptibility, and/or access to care, reflecting biological and social components of epidemics. Some potential differences in exposure are suggested by the limited descriptions of institutional life available in the records. Generally, staff brought the disease into the institutions, although subsequent employee-to-patient and patient-to-patient transmission were possible. Staff sometimes slept in the same room as patients (Kringlen 2004), but by the time of the pandemic, this practice was less common. Isolation and restriction of activities likely were important in preventing the spread of disease once it entered an institution. However, based on archival material including photographs and floorplans, most patients (and students at the boarding schools) stayed in large open rooms of 8–12 beds, and not all institutions had rooms available to isolate infectious cases. The psychiatric institutions were overcrowded which would promote transmission, yet the most overcrowded one, Opdal, had the lowest patient morbidity. Required segregation of patients could explain sex differences, e.g. the timing of outbreaks in different wards. Significant case fatality differences between patients and staff were observed at Møllendal, which was not particularly noteworthy in terms of size, location, or responses to the outbreak. It was, however, the only institution in the sample that was privately operated (Medical Director 1921), so population characteristics or institutional practices might have differed from public facilities.

Table 3: Share and relative odds of morbidity by patient status, age, sex, and institution.

Covariates	N (%) Not Sick	N (%) Sick	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 4 OR (95% CI)
Patients	977 (76.2)	305 (23.8)	0.272 (0.212–0.350)*	0.394 (0.301–0.516)*	0.402 (0.307–0.527)*	0.392 (0.298–0.516)*
Employees	157(46.6)	180 (53.4)	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
10–19	24 (42.1)	33 (57.9)		1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
20–29	192 (51.9)	178 (48.1)		0.735 (0.412–1.311)	0.714 (0.399–1.277)	0.620 (0.344–1.117)
30–39	312 (69.8)	135 (30.2)		0.429 (0.239–0.768)*	0.415 (0.231–0.746)*	0.371 (0.205–0.670)*
40–49	271 (79.9)	68 (20.1)		0.259 (0.141–0.477)*	0.250 (0.135–0.461)*	0.213 (0.115–0.397)*
50–59	196 (78.4)	54 (21.6)		0.297 (0.159–0.557)*	0.285 (0.152–0.537)*	0.242 (0.127–0.458)*
60–69	139 (89.1)	17 (10.9)		0.137 (0.065–0.290)*	0.133 (0.063–0.281)*	0.114 (0.053–2.43)*
Males	606 (72.0)	236 (28.0)			1.00 (Ref)	1.00 (Ref)
Females	528 (68.0)	249 (32.0)			1.182 (0.942–1.484)	1.288 (1.015–1.634)*
Eg	272 (73.9)	96 (26.1)				0.721 (0.512–1.017)+
Neevengaarden	249 (68.6)	114 (31.4)				1.00 (Ref)
Dale	195 (75.0)	65 (25.0)				0.674 (0.460–0.989)*
Valen	148 (61.9)	91 (38.1)				1.348 (0.934–1.945)
Opdal	131 (75.7)	42 (24.3)				0.634 (0.407–0.986)*
Rosenberg	67 (58.3)	48 (41.7)				1.966 (1.219–3.172)*
Mollendal	72 (71.3)	29 (28.7)				0.944 (0.564–1.580)
N			1619	1619	1619	1619
−2 log likelihood			1872.370	1800.254	1798.177	1766.024
Nagelkerke R²			.089	.147	.148	.173

* p < 0.05.
+ p < 0.10.

Table 4: Chi-square results testing association between patient status and case fatality.

Comparisons	ILI Cases	ILI Deaths	ILI Survivors	Case Fatality (Deaths/Cases, %)	Chi-Square Results
Both Sexes					
Patients	305	30	275	9.84	X^2 = 13.983
Employees	180	2	178	1.11	P = 0.000
Males					
Patients	166	17	149	10.24	X^2 = 5.427
Employees	70	1	69	1.43	P = 0.02
Females					
Patients	139	13	126	9.35	X^2 = 8.250
Employees	110	1	109	0.91	P = 0.004

Differential access to health care likely cannot explain disparities, as no effective vaccines, antivirals, or antibiotics were available; much of the survival and recovery during the pandemic has been attributed to general nursing care (Mamelund 2011). However, stigma, social attitudes, and inaccurate understanding of disease and disability may have affected the quality or provision of health care within the institutions. Further, there is limited information on whether ill staff members were replaced by even untrained substitutes. With the high rate of morbidity among staff members, relatively few caretakers might have been responsible for both the patients and sick staff who were unable to return home. Nonetheless, the higher CFR among patients despite lower morbidity suggests differences in susceptibility to complications or adverse outcomes from influenza.

Limitations of this study include a lack of information on individual-level diagnoses, preventing exploration of potential interactions between specific disabilities and influenza. Further, while annual reports listed other health conditions, patient data are not available for investigating the role of conditions that increase the risk of severe influenza (e.g. diabetes, cardiovascular disease, severe obesity). Outcomes also might reflect previous epidemics, which could have provided some immunity to similar strains or co-circulating pathogens or alternatively could have weakened pre-existing health among residents. Reports documented that schools experienced frequent epidemics in preceding years of diseases including influenza, chickenpox, measles, mumps, rubella, pertussis, and scarlet fever (Bjørset 1914; The Public School for the Deaf in Trondheim 1914). Finally, we have no information on pandemic cases or deaths among individuals in the area with disabilities who were not in institutions. Similarly, results might not be generalizable to other institutions.

Implications for preparedness planning

The complex interactions of social and biological variables contributing to observed differences reinforce the need to thoroughly and explicitly consider people with disabilities when preparing for future pandemics. As a diverse population with legal and political rights that must be considered, it is insufficient to group people with disabilities under the broad and vague umbrella of chronic medical conditions or vulnerable populations. Rather, both immediate and long-term, systemic efforts are needed, including practical implementation strategies and tools for assessing the effectiveness of different measures. Critical examination of current plans illustrates the relative lack of consideration for social inequalities in general (Mamelund 2017) and for people with disabilities specifically. To ensure more inclusive and equitable actions, people with disabilities should be included in the development of plans. In a study of disabled people's organizations engaged in disaster preparedness activities, Pertiwi, Llewellyn, and Villeneuve (2019) found that participants were strongly motivated by the lack of attention during previous disasters. These organizations are more likely to be accepted and trusted by affected populations and so play crucial and timely roles at the community level (Pertiwi, Llewellyn & Villeneuve 2019). As Janes and Corbett (2009) observed, local populations may suffer unintended consequences in the implementation of public health policies created at the global or national level. Therefore, advocacy for potentially overlooked populations and awareness of how policies are communicated and manifest on the ground are essential. The cultural expertise and social networks of people with disabilities are vital resources for addressing disability-related issues, as well as for creating inclusive plans that account for the many people who might be temporarily disabled during health crises and the resulting disruptions to social and economic life (Fjord & Manderson 2009; Gerber 2009).

Further, the present study has particular relevance for people with disabilities who are institutionalized. Institutionalization reflects factors such as severity of the condition, socioeconomic circumstances of the individual or their family, and social attitudes regarding disability. For example, around the time of the 1918 pandemic, eugenics beliefs would have played important roles in decisions such as whether someone should be placed in a psychiatric hospital or whether a child was seen as capable of being taught, even at a school for children with disabilities. Taking a social model perspective, individuals might be institutionalized because they have impairments that are considered to

be severe, but the physical and social environment of institutions create or further contribute to disability status as well. Within institutions, patterns of interpersonal contact, neglect or mistreatment, and the availability and quality of health care can contribute to the spread of epidemics. Despite deinstitutionalization efforts, many people with disabilities still reside in facilities today, including smaller congregate living homes, prisons, and nursing homes (WHO 2011; Krahn, Walker & Correa-De-Araujo 2015). Recent estimates for the United States indicate that approximately 4 million people are institutionalized (Taylor 2018), while 0.01–5.2% of pupils in EU member states attend segregated schools (European Commission 2012). Although these people represent a fraction of the total population with disabilities, they are also more likely to have more severe disabilities or poorer health. Smaller establishments may not be regulated, and one study found that only 45% of surveyed residential care facilities had an existing pandemic plan (Lum et al. 2014). The historical data presented here show that people with disabilities residing in institutions had worse mortality outcomes than staff, and that some outcomes, such as the morbidity-mortality crossover, might be counterintuitive. Results support deinstitutionalization arguments and demonstrate the need for better preparedness planning among various types of institutional living facilities and schools today.

While some disability models suggest it is difficult, if not impossible, to tease apart biological and social/environmental factors that produce differential outcomes, future research can still document disparities and identify variables that might contribute to or prevent them. For example, biomedical research on interactions of influenza with specific disabilities could identify synergistic mechanisms that produce complications, increased susceptibility, or reduced vaccine efficacy. Historical and cross-cultural studies are necessary to determine the extent of variation across different cultural contexts and the dynamics of past experiences, especially because the majority of work on disability and influenza discussed above has only used samples from the United States and northern and western Europe, with the exception of several studies in Asia. Further, similar arguments can be extended to link disabilities to other types of infectious diseases. Ultimately, nuanced consideration of disability is necessary for effective and equitable pandemic preparedness plans and policies.

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The authors have no competing interests to declare.

Author Contributions
Both authors contributed to the concept and design of this work. JD collected archival data, while SEM provided additional published data. JD drafted the manuscript, which both authors reviewed and approved for publication.

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