SSM - Population Health 23 (2023) 101474

Contents lists available at ScienceDirect

SSM - Population Health

journal homepage: www.elsevier.com/locate/ssmph

Racial-ethnic, gender identity, and sexual orientation disparities in COVID-19-related social and health outcomes: A decomposition analysis

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ARTICLE INFO

Keywords:
Health inequality
COVID-19
Unmet resource needs
Gender and sexual minority
KHB-Method

ABSTRACT

Despite the growing literature on racial-ethnic disparities during the pandemic, less is known about the explanatory mechanisms of these disparities and inequalities across other axes, such as gender and sexual identities. We studied the levels and sources of racial-ethnic, gender identity, and sexual minority disparities in social (i.e., unmet resource needs) and health (i.e., hospitalization) outcomes among individuals diagnosed with COVID-19, hypothesizing differential age structure, underlying health, and work and living arrangements as contributors to inequalities. Using large-scale administrative data from Chicago and adjusting for covariates, we found substantial racial-ethnic and gender identity disparities in both outcomes, and weak evidence of sexual minority disparities in unmet needs. Subsequent decomposition analyses revealed that living in larger households, having a higher share of non-adult cases, and facing higher burdens of chronic illness, obesity, and unemployment each statistically significantly drove racial-ethnic disparities in unmet needs, but these together explained less than 15% of the disparities. Similarly, about 20% of the Black-White gap in hospitalization resulted from disparities in underlying health and unemployment, whereas a higher proportion of non-adult cases or higher unemployment rates respectively proved the only significant pathways to partially explain transgender individuals' disadvantages in unmet needs (12%) or hospitalization (6%). These findings highlight the importance of considering multiple dimensions of social differences in studying health disparities, the vulnerabilities of transgender and non-adult communities during the pandemic, and the valid yet quite limited roles of previously suggested sociodemographic factors in accounting for COVID-19-related categorical inequalities.

1. Introduction

While a long-standing literature underscores the fundamental connection between social status and health (Clouston & Link, 2021), research on COVID-19 highlights the persistence and aggravation of health disparities. In the US, racial-ethnic minorities and those with fewer socioeconomic resources disproportionately face higher risks of COVID-19 infection and mortality (Fielding-Miller et al., 2020). Studies reveal multiple mechanisms that pose challenges to socially under-resourced people. These challenges include delayed testing access, difficulties in indoor physical distancing, reduced access to healthy food, and secondary stressors such as job insecurity and psychological distress (Ali et al., 2021; Daly et al., 2022; Saenz & Sparks, 2020; Servick, 2020; Vedovato et al., 2022).

Equally importantly, researchers are starting to explore the *link* between various social determinants of health (SDH) and categorical disparities. This line of literature, while still nascent, carries out a critical task: It will illuminate the sources of categorical disparities in the aftermath of the pandemic and inform targeted interventions (Dalsania et al., 2022). Research in this regard has focused on disentangling racial-ethnic inequalities in COVID-19, attempting to identify the socioeconomic, geographic, and behavioral contributors to the observed gaps. Higher-poverty US areas have exacerbated racial-ethnic disparities in COVID-19 deaths (Dalsania et al., 2022), which parallels global-scale research showing that regional wealth and chronic illness burden explain geographic disparities in pandemic mortality (McGowan & Bambra, 2022). Non-English-speaking, an attribute more common among ethnic minorities, also appears a contributor to racial-ethnic inequalities in COVID-19 hospital admission (Karmakar et al., 2021). Also considered are working and living arrangements. Several studies found a

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https://doi.org/10.1016/j.ssmph.2023.101474
Received 14 April 2023; Received in revised form 21 July 2023; Accepted 21 July 2023
Available online 23 July 2023

higher prevalence of essential workers among Black individuals, relating it to higher COVID-19 mortality (Karmakar et al., 2021; Rogers et al., 2020). However, in Lee et al.'s (2022) study, factors including lower education levels, more crowded living, and increased remote work could not explain Hispanic Americans' higher infection rates than White Americans. Additionally, the authors did not find higher infection rates among Black Americans.

These results are suggestive but also illustrate the preliminary status of current research. While scholars have examined many SDH that may serve as proximate pathways for COVID-19 disparities, we know little about *how much* disparity is explained by these pathways, and how much contribution *each* pathway makes. The limitation here is partly methodological. Existing studies used either correlational methods or the direct comparison of coefficients across regression models. These methods give us initial intuition about potential pathways but cannot disentangle the degree of categorical disparities that is attributable to each factor. Further, recent developments in mediation analysis show that these traditional methods may not yield correct estimates or significance levels (Karlson et al., 2012; Zhao et al., 2010). In other words, we have knowledge gaps not only in terms of the magnitude of SDH influences on health disparities, but potentially also in question is the validity of existing conclusions regarding the presence or absence of those influences.

Another issue is the lack of systemization in current knowledge. Findings from extant results seemed to differ depending on the focal social category (e.g., Black versus Hispanic individuals) and outcome of interest (e.g., infection versus mortality). Scholars are yet to formulate a more comprehensive understanding of the intersectional contexts whereby specific types of categorical disparities are more subject to SDH influences (Harari & Lee, 2021). This necessitates inquiry into diverse forms of health inequities in terms of both social group divisions and outcomes of interest. Certainly, this task requires cumulative efforts from multiple studies. But scholars can begin by becoming reflexive of the likely context-specific nature of one's findings and by incorporating more dimensions of inquiries.

For example, what explains vulnerabilities of persons with disabilities, children, older adults, or gender and sexual minority individuals? How do categorical disparities vis-à-vis COVID-19 extend to life outcomes beyond physical health, such as housing, mental healthcare access, caregiving responsibilities, and so on (Ruprecht, Wang, Johnson, Xu, & Felt, 2021)? We extend prior work by addressing some of these questions. We also adopt newer methods that allow to tease out the relative contribution of SDH and demographic composition in explaining categorical disparities.

We use the Case Investigation and Contact Tracing (CICT) data from the city of Chicago for this study. As the third-most populous city in the US and long-documented for its high levels of residential segregation (Sampson, 2012), Chicago witnessed both extensive outbreaks and drastic disparities pertaining to the COVID-19 pandemic. By mid-January 2022, the city reported over 440,000 COVID-19 cases and over 25,000 COVID-19-related hospitalizations, making it the jurisdiction with the largest COVID-19 case burden in the Midwest (City of Chicago, 2022). Significantly, minority populations were disproportionately affected by COVID-19 incidence and mortality. In 2020, over 60% of COVID-19-related deaths and over 50% of COVID-19 infections occurred among Black communities while the city's Black population is about 30% (Ruprecht et al., 2021). Meanwhile, the Chicago metropolitan area is home to 298,000 LGBT residents (Williams Institute, 2021), who also reportedly face health and economic challenges during COVID-19 (Ruprecht et al., 2021).

Against these backdrops, the CICT data were derived from the COVID-19 response by the Chicago Department of Public Health, where positive cases were interviewed to conduct contact tracing and to assess the uneven impacts of COVID-19 across the city's diverse social landscape. Capitalizing on the CICT data, this paper aims to accomplish two goals. First, we ascertain the level of systematic racial-ethnic, gender identity, and sexual orientation disparities among COVID-19 cases in hospitalization and unmet resource needs; second, we examine and quantify the role of various sociodemographic factors in accounting for observed disparities.

2. Literature and framework

We make two lines of effort to expand the dimensions of COVID-19 inequality inquiry. First, regarding social groupings, we include race-ethnicity, but also consider gender identity and sexual orientation, two other axes of structural inequalities that have received less attention. While social studies of COVID-19 have factored in gender inequity (Mize et al., 2021), most focus on cisgender individuals, omitting gender minority individuals whose gender identity differs from sex at birth or transcends the male-female binary. Meanwhile, there have been extensive concerns that sexual and gender minorities (SGM) endure significant disadvantages vis-à-vis COVID-19. Scholars theorize that the toll of SGM stigma is exacerbated during the pandemic, showing evidence of curtailed gender-affirming care, reduced access to HIV preventive programs, increased economic insecurities, higher chronic-illness burden, and elevated levels of mental disorders and substance abuse (see Drabble & Eliason for a review, 2021). For example, researchers using the national COVID-19 Impacts Survey found that compared with cisgender peers, transgender individuals had higher odds of experiencing COVID-19 symptoms (Phillips et al., 2021), housing instability and medical care interruptions (Felt et al., 2023). Nonetheless, systematic evaluations of gender and sexual minority status as a determinant for COVID-19 outcomes remain sparse, especially given that most studies are theoretical or qualitative, whereas the few quantitative examinations are constrained by small sample sizes and/or non-random sampling procedures (Nowaskie & Roesler, 2022; Ruprecht et al., 2021). Moreover, current research is descriptive in nature: no quantitative study has sought to associate the observed gaps with SDH *explanations*.

In this light, the CICT data offer a large sample size and detailed coverage of gender identity and sexual orientation questions, and we provide a systematic assessment of COVID-19 disparities along the gender and sexual minority identities. Additionally, informed by the call for attention to multiple axes of oppression and structural inequalities (Collins, [1990] 2022; Settles & Buchanan, 2014; Vargas et al., 2020), we also visualize the combined effects of race-ethnicity, gender identity and sexual orientation.

Additionally, regarding outcomes of interest, we study hospitalization and unmet resource needs during self-isolation to cover both medical and social aspects of COVID-19 consequences. Existing studies mostly address medical outcomes such as infection, hospitalization, mortality, and vaccination (Ali et al., 2021; Rivera et al., 2020; Reitsma et al., 2021). A growing literature has also investigated the differential impact of COVID-19 on social and economic conditions by race and gender identity, surveying outcomes like job loss, unemployment benefit access, domestic labor division, and school continuation (Hardy & Logan, 2020). However, fewer studies explore whether individuals encounter unmet needs for resources and support as a result of COVID-19. A need-based analysis is valuable as it provides an all-inclusive lens on the impact of COVID-19 from people's own point of view; it also features actionable problems that require policy attention. Within the limited research in this direction, studies often center on (mental and physical) healthcare needs (Ormiston & Williams, 2022; Thomeer et al., 2022). To our knowledge, only one small-sample ($n = 200+$) study examined inequities in unmet needs more comprehensively, considering diverse types of resources that include but also go beyond healthcare access: e.g., food, protective supplies, technology use, and community support (Ruprecht et al., 2021). In both cases, authors found higher unmet needs levels among minority populations.

In this regard, we avail ourselves of the CICT questionnaire that asks individuals to list issues they need external support for during COVID-19, and we probe whether and how categorical inequalities exist in

the odds of having unmet resource needs. Importantly, we also investigate the outcome of hospitalization, given the literature's gap in understanding gender and sexual identity disparities and in the mechanisms for categorical disparities.

Last but not least, we attempt a decomposition analysis of group differences using the KHB-method—a mediation analysis technique suitable for nonlinear probability models (Karlson et al., 2012)—to assess the socioeconomic and demographic features that contribute to observed categorical differences. Specifically, we look into the roles of 1) age structure, 2) health conditions and behavior, 3) work arrangements, and 4) household characteristics.

While previous studies used age exclusively as a control variable to predict COVID-19 medical outcomes (Karmakar et al., 2021), we explore age composition as a potential explanation for differential unmet need levels. Reports depict teens and younger individuals as hardest hit during COVID-19 both economically (Crozet, 2022) and psychologically (Weissbourd et al., 2022). As racial-ethnic minorities and LGBTQ + people are also on average younger than White and non-queer individuals (Selden & Berdahl, 2020; Williams Institute, 2017), it is possible that younger age drive disparities in unmet needs.

For health-related attributes, we include chronic illness to test whether higher pre-existing condition prevalence among diverse individuals leads to wider categorical gaps in COVID-19 outcomes (Heslin & Hall, 2021; Karmakar et al., 2021). We also consider obesity for racial-ethnic disparities, as it disproportionately affects Black and Hispanic individuals while aggravating COVID-19 (Petersen et al., 2019; Yang et al., 2021). These health-related mechanisms may apply to both hospitalization and unmet needs because underlying conditions affect COVID-19 severity but can also be debilitating to everyday life.

Regarding work situations, we follow previous research to consider essential work, a key proxy of viral exposure and occupational status (Karmakar et al., 2021; Lee et al., 2022), positing that racial-ethnic minorities' disproportionate allocation in higher-risk, lower-paid industries may contribute to higher unmet needs and hospitalization. Given evidence of higher unemployment rates among racial-ethnic, gender and sexual minority populations during the pandemic (Couch et al., 2020; Martino et al., 2022), we also gauge the role of (un) employment status in creating observed disparities.

For household characteristics, we again reference prior studies to measure household size and congregated living status (Gillies & Rowlands, 2022; Lee et al., 2022). Increased co-residents can create household resource constraints when family members contract COVID-19 (Yan et al., 2021). Since racial-ethnic minorities tend to have larger households than White individuals (Census Bureau, 2016), we suspect that more congregated living arrangements may augment disparities especially along racial-ethnic lines.

Overall, we hypothesize that 1) racial-ethnic disparities in unmet needs are partly driven by racial-ethnic minorities' younger age structure, higher prevalence of pre-existing health conditions, essential worker status, unemployment, larger household size, and congregate work and living settings; 2) These factors, except for age, contributes to racial-ethnic hospitalization disparities (see Fig. 1). As for gender and sexual minority disparities, the limited prior research gives us less clue as to whether disparities exist for both outcomes, whether gender versus sexual minority indicates disadvantages in similar ways, and still less guidance on the sociodemographic mechanisms. As such, we preliminarily postulate identical hypotheses for gender and sexual minority individuals (grouped together in Fig. 1), although analyses will be conducted separately for these conceptually distinct groups. Specifically, while the literature hinted at the pathways of younger age, higher rates of unemployment and underlying conditions, we examine these pathways but also explore the roles of other mediators studied for racial-ethnic disparities (solid vs dotted lines in Fig. 1).

3. Methods

3.1. Data

Starting in March 2020, all SARS-CoV-2 laboratory positive cases in the city of Chicago were reported to the Chicago Department of Public Health (CDPH). As part of CDPH's Case Investigations and Contact Tracing (CICT) initiative, the CICT team attempted to reach out to each case to collect demographic, behavioral and contact tracing information. Those that were successfully reached are administered a case investigation questionnaire. The questionnaire covers a range of questions for public health and social research purposes, including the respondent's demographic information, occupation, work and living settings, clinical conditions, supports needed for COVID-19, as well as their close contacts over the past two weeks.

The CICT data we use for this analysis cover all the 50,846 COVID-19 positive cases who completed the interview between September 16, 2020 and January 13, 2022. This sample accounts for about 11.4% of all individuals who tested positive during this period (City of Chicago, 2022). Some outreach attempts were met with non-response, due to reasons such as the individual being at work or COVID-19 fatigue especially during late 2021. Additionally, due to the limited staff capacity, there is a time gap between an individual's positive result confirmation and the interview completion; this lag can be especially pronounced during surge periods.

We note that some questions in the survey are optional, which leads to significant missingness in certain variables (Table 1). To address missingness in the data, we attempted 1) multiple imputation by

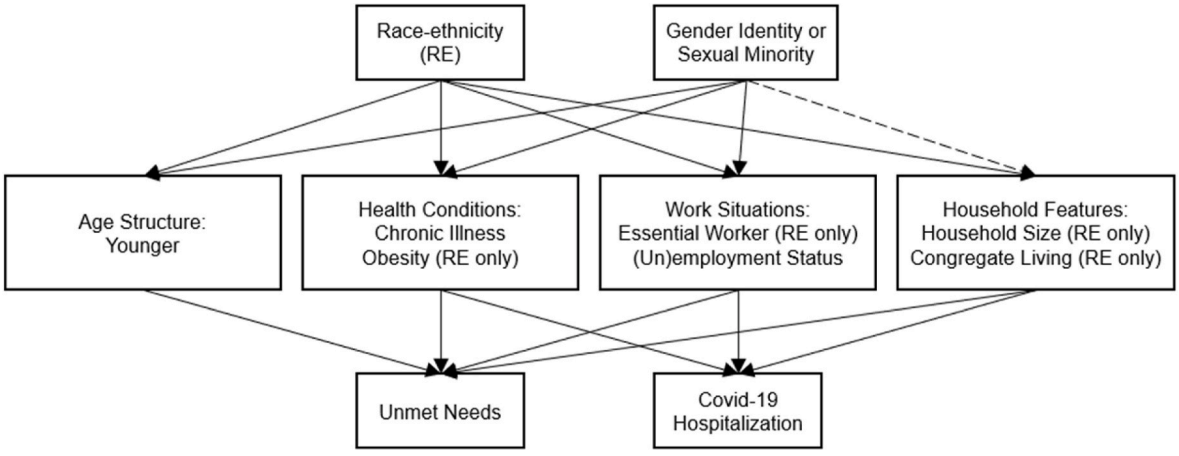


Fig. 1. Conceptual diagram of hypothesized pathways.

Table 1
Descriptive statistics of full sample and by groups.[a].

	Percentage or Mean (SD)									
	Full Sample	*Race-ethnicity*				*Gender*			*Sexual Orientation*	
		NH White	Hispanic	NH Black	NH Other	Cis male	Cis female	Transgender	Straight	Sexual Minority
Unmet needs[b]	6.2	2.1	7.4	9.2	6.1	6.0	6.5	9.2	6.1	7.1
Hospitalized	1.0	0.6	0.6	2.2	1.0	1.0	1.1	3.3	1.1	1.2
Age	34.0 (18)	34.8 (18)	32.5 (18)	35.7 (20)	32.3 (18)	33.4 (18)	34.6 (18)	33.9 (19)	34.5 (18)	33.6 (12)
Chronic illness[c]	26.3	21.6	23.7	38.0	23.1	25.0	27.5	30.4	27.7	34.9
Obese	9.4	6.5	10.2	13.3	7.9	7.6	11.1	10.9	9.9	11.0
Employment Status										
Employed	51.9	62.4	47.5	49.5	47.7	54.9	50.1	46.8	55.0	71.7
Retired	5.0	5.56	3.28	7.36	4.36	4.8	5.3	6.2	5.1	2.01
Student	18.6	16.2	21.2	16.6	20.9	19.3	17.2	20.1	16.5	9.32
Unemployed	24.5	15.9	27.9	26.5	27.1	20.9	27.4	26.9	23.4	17.0
Essential worker	10.8	10.1	10.1	13.6	10.4	11.2	10.8	9.4	12.6	16.5
Congregate living	0.3	0.3	0.1	0.4	0.3	0.2	0.3	0.5	0.2	0.6
Household size	3.3 (1.9)	2.7 (1.7)	3.9 (1.9)	3.1 (1.8)	3.6 (2.0)	3.3 (1.9)	3.4 (1.9)	3.3 (1.7)	3.4 (1.9)	2.4 (1.5)
No. Of obs. % of valid obs.	50,846,100.0	10,646 24.1	17,017 38.5	11,950 27.0	4608 10.4	21,836 45.4	25,646 53.3	607 1.3	17,690 96.4	661 3.6
No. (%) of missing obs.	–	6625 (13.0)				2757 (5.4)			32,495 (63.9)	

[a] Data source: CICT data of positive COVID-19 cases in Chicago who were interviewed between Sep 16, 2020, and Jan 13, 2022.
[b] Asks whether the respondent reports needing any additional support during self-isolation (e.g., childcare, housing, heating, medical care etc.).
[c] Includes asthma, lung disease, heart disease, liver disease, diabetes, kidney disease, hypertension, seizures, cancer, and immunocompromised.

chained equations (MICE, m = 20 iterations), and 2) the missing indicator method (MIM) (Sperrin & Martin, 2020). Results are similar between both methods, and we report main modeling findings from MICE, given its higher accuracy in error estimation (Little & Rubin, 2019). For decomposition, however, we resort to MIM due to the absence of existing algorithms to implement the KHB-method for multiply imputed data.

3.2. Variables

3.2.1. Dependent variables

The first outcome of interest is a dichotomous measure of having *unmet needs*. The CICT survey contains a question where respondents are asked to report the types of support they need during their self-isolation. A checkbox list is provided for the question, including childcare, housing, prescriptions, non-COVID medical care, mental health support, substance abuse support, translation/interpretation, disability accommodations, cell phone service, internet, heat/AC, pet care, and an "Other" option. While most individuals left this question as blank, some specified their needs. The variable unmet needs is coded as "yes" if an individual checked at least one item (including Other) for the question, and "no" otherwise.

Another outcome is *hospitalized*, which is a dummy coded as "yes" if a respondent reported being hospitalized for COVID-19 after diagnosis.

3.2.2. Key predictors

Our key predictor variables are race-ethnicity, gender identity, and sexual orientation. We recode *race-ethnicity* information from the CICT data into five categories: Hispanic, non-Hispanic (NH) White, NH Black, and NH Other (Asian, Other Race/Other, mixed race, and Native American).

We measure *gender identity* using two contiguous questions: Sex at birth ("What was your sex at birth?") and gender identity ("How do you currently identify your gender?"). We code an individual as "cis man" or "cis woman" if they 1) provide either the same response to the sex at birth and gender identity questions as male/female, or 2) only answered male/female in the sex at birth question. An individual is coded as transgender if they 1) explicitly suggest a trans or nonbinary gender in the gender identity question, or 2) reported non-missing and discrepant answers for the sex at birth and gender identity questions.

We note several considerations in devising this coding strategy. First, we impute missingness in gender identity using sex at birth. Likely because 1) both questions are optional, 2) the sex at birth question precedes the gender identity question, and 3) an estimated over half of Americans today consider gender as automatically implied from biological sex (Pew Research Center, 2022), 41% of respondents in the CICT survey skipped the gender identity question while missingness was only 1.7% for sex at birth. Also given research showing that survey response rates are often higher among sexual and gender minority individuals than non-minorities (Bates et al., 2019; Lee et al., 2018), we thus infer as cisgender those who skipped the gender question but responded "man" or "woman" for sex at birth. Second, we classify as transgender individuals whose identity is "man" or "woman" but different than their sex at birth (n = 581, 1.1%). While research is wanting in this regard, many transgender persons reportedly prefer to identify as woman/man and downplay the gender-transitioning aspect of their identity (Folk, 2022). Note that for both these decisions, the alternative strategy of coding gender based solely on the gender identity question yields substantively similar results.

Third, we refrain from a further classification than transgender for non-cis persons. While the original questionnaire included multiple categories for gender minorities (non-binary or genderqueer person (n = 15, 0.03%), a gender identity not listed (n = 4, 0.008%), transgender woman (n = 11, 0.02%), transgender man (n = 16, 0.03%)), the sample sizes are too small for separate analyses of each category. Fourth, we retain the cis men and cis women distinction to ascertain potential gender disparities within cisgender individuals.

A separate question exists in the questionnaire for *sexual orientation*. A respondent is classified as sexual minority if they identify with bisexual (n = 135, 0.3%), gay or lesbian (n = 462, 0.9%), queer (n = 26, 0.05%), questioning (n = 10, 0.02%), or another orientation (n = 28, 0.06%), and straight if they chose the option of straight or heterosexual. Those who answered unknown, skipped or declined to answer the question are coded as missing. Again, we combine the minority categories for measurement: Although the absolute counts for the bisexual and homosexual categories are not too small, not enough individuals in each category reported "Yes" for the outcome variables (e.g., n = 0 for hospitalized and n = 14 for unmet needs for bisexual individuals) for meaningful statistical analyses.

3.2.3. Other predictors

We consider four mediating pathways for categorical disparities in

unmet needs. We measure *age* structure using a piecewise linear function (Harrell, 2001) to capture its nonlinear relationship with unmet needs, with a distinct slope estimated for each age group (<18, 18–39, 40+) and an intercept term of whether the respondent is younger than 18 (Supplement S2.1). Health conditions include dummy variables of *chronic illness* (i.e., asthma, lung disease, liver disease, diabetes, kidney disease, hypertension, seizure, cancer, immunocompromised) and *obesity*. Work situations include a dummy variable for *essential worker*, and a four-category predictor of *employment status* (employed, unemployed, student and retired). Household features involve a dummy of *congregate living* (e.g., homeless shelters, assisted living facilities, group homes, prisons, detention centers) and a piecewise numeric measure of *household size* with 10 as the cut-point for separate slopes (S2.2).

For hospitalization, we test the same mediators except for age and household size. Age will be included as a control variable rather than mediator, and no piecewise transformation will be imposed. Household size will be tested as a mediator that has three categories: living alone, 2-person, vs 3+ person households. This coding is derived from research that found higher risk of severe COVID-19 among households with 1 or 3+ persons (Gillies & Rowlands, 2022).

3.3. Analytic strategies

We assess the extent of categorical disparities through a combination of summary statistics and multiple logistic regressions. The logistic model estimates are pooled from each imputed dataset. Respectively for the two outcomes, two base models are fitted with race-ethnicity (Models 1,4) or gender identity and sexual orientation (Models 2,5) alone, before all other predictors are added in Models 3 and 6. We use these models to 1) ascertain and compare categorical differences before and after adjusting for socio-demographic attributes, and 2) explore the association between the outcomes and the proposed pathway mediators. For goal 1), note that one cannot directly compare coefficients' magnitude across nonlinear models, but changes in p-values and effect direction are reliable indicators for comparison (Harrell, 2001).

We then employ the KHB-method to model the mediation effects of the hypothesized socio-demographic pathways for observed categorical disparities. The KHB-method offers an intuitive approach to decomposing key variable effects (e.g., race-ethnicity) into direct and mediator effects for nonlinear models with discrete outcomes (Karlson et al., 2012). Its results will inform us on 1) the effects of individual mediator variables, and 2) the proportion of categorical disparities explained by the pathways. All analysis, including MICE and KHB, is conducted in R software (V4.2.2).

4. Results

4.1. Descriptive statistics

Table 1 shows summary statistics for the full sample and separately by race-ethnicity, gender identity, and sexual orientation. Marked racial-ethnic disparities are observed for both outcome variables (χ^2 tests $p < 0.0001$). The rate of having unmet needs for Black (9.2%), Hispanic (7.4%), or other-race (6.1%) participants is about 3–4.5 times as high as White participants (2.1%). Black participants also had higher rates of hospitalization (2.2%) after infection than other groups (overall mean = 1.0%). Additionally, we detect gender-minority (χ^2 tests $p < 0.0001$) but not sexual-minority disparities (χ^2 tests $p > 0.4$) in the outcomes. 9.2% of transgender individuals had unmet needs during self-isolation, about 50% higher than cisgender individuals. Hospitalization was also more frequent for transgender participants (3.3%) than the overall sample (1.0%). Yet for both outcomes, the rates are similar between sexual minority and straight participants.

Minority populations also exhibit many of the socio-demographic traits that we hypothesized as pathway linkages to adverse outcomes (χ^2 and ANOVA tests $p < 0.0001$). All racial-ethnic minority groups had higher prevalence of chronic illness, obesity, and unemployment, and larger household sizes than White participants. A higher-than-average proportion of Black participants were essential workers or lived in congregate settings, whereas Hispanic and other-race individuals were younger in age. Regarding gender identity and sexuality, transgender and sexual minority participants had higher levels of chronic illness and congregate living. Obesity and unemployment rates were also higher among transgender than cisgender participants, while a greater percentage of sexual minority than straight respondents were essential workers.

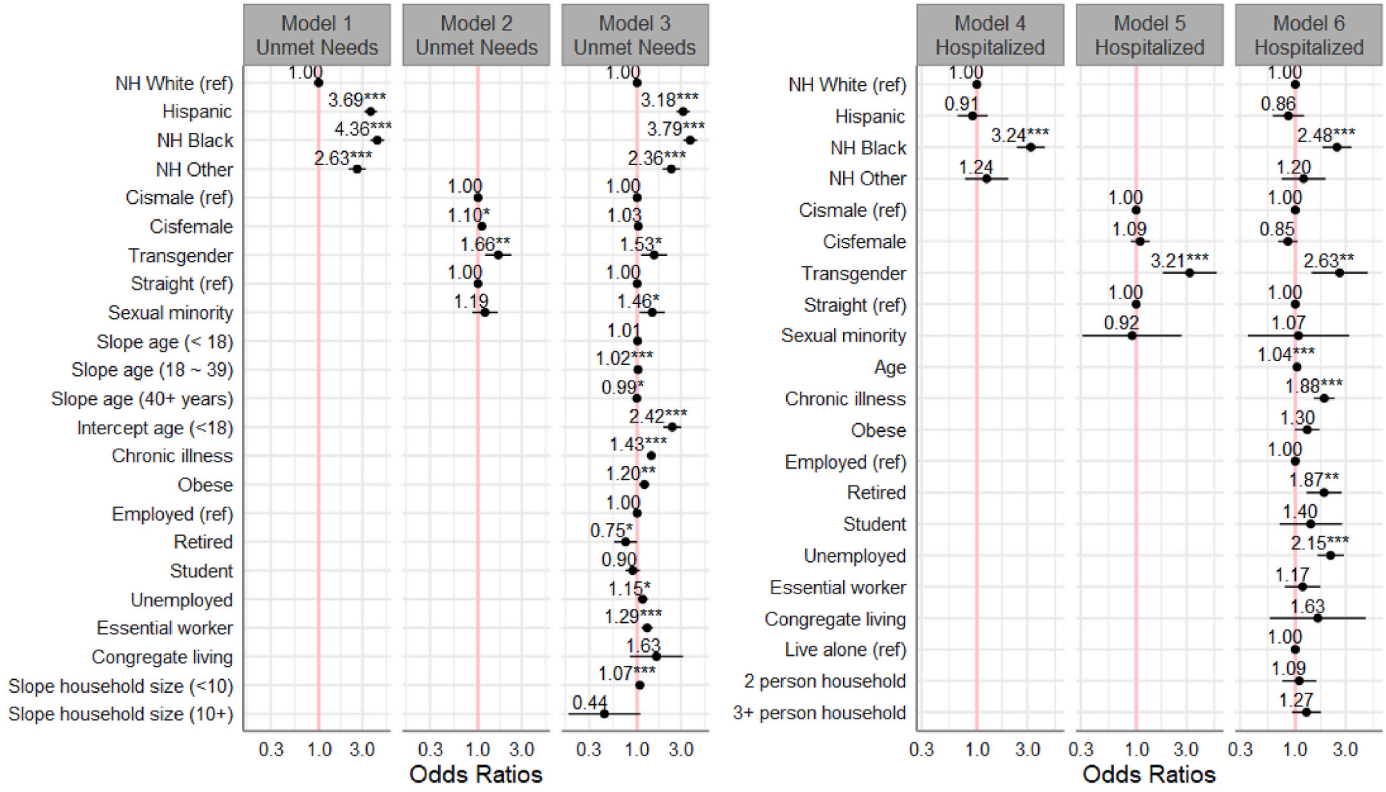
4.2. Logistic models

Logistic regression results are reported in Fig. 2. The models confirm the presence of large racial-ethnic and gender disparities, with the additional finding that the proposed pathways partially explain these disparities. The odds of unmet needs among Black, Hispanic, and other-race individuals are respectively 4.4 (CI = 3.7–5.2), 3.7 (CI = 3.1–4.3), and 2.7 (CI = 2.1–3.3) times the odds of White individuals in the base model (Model 1). The effects are weakened—but only slightly so—to 2–4 times in Model 3 after adding covariates. The OR estimates of unmet needs for transgender individuals are also marginally reduced from 1.7 (CI = 1.2–2.3) to 1.5 (CI = 1.1–2.1) from the base Model 2 to Model 3, though the lower significance levels ($p < 0.001$ to $p < 0.01$) evidences a reduction in effect size. Similarly, according to Models 4 and 5, Black and transgender individuals are each predicted to be over 3 times as likely in the odds of hospitalization as White and cis male individuals (CI = 2.4–4.4, 1.8–5.8 respectively). Yet the additional predictors in Model 6 slightly lessened the estimates to 2.5 times (CI = 1.8–3.4, 1.4–4.8), with again reduced significance level ($p < 0.001$ to $p < 0.01$) for transgender effects.

The coefficients for sexual minority are also worth noting. For hospitalization (Models 5 and 6), consistent with descriptive findings, no sexual-minority disparities are discerned. Yet regarding unmet needs, while the base Model 2 shows no sexual minority-related differentials, in Model 3, sexual-minority individuals are predicted to experience 50% higher odds of unmet needs after adjusting for covariates (CI = 1.1–2.0). This suggests a possible suppression effect here. That is, sexual-minority individuals were advantaged in certain socio-demographic covariates, which conceals the adverse impact of their sexual orientation on social needs.

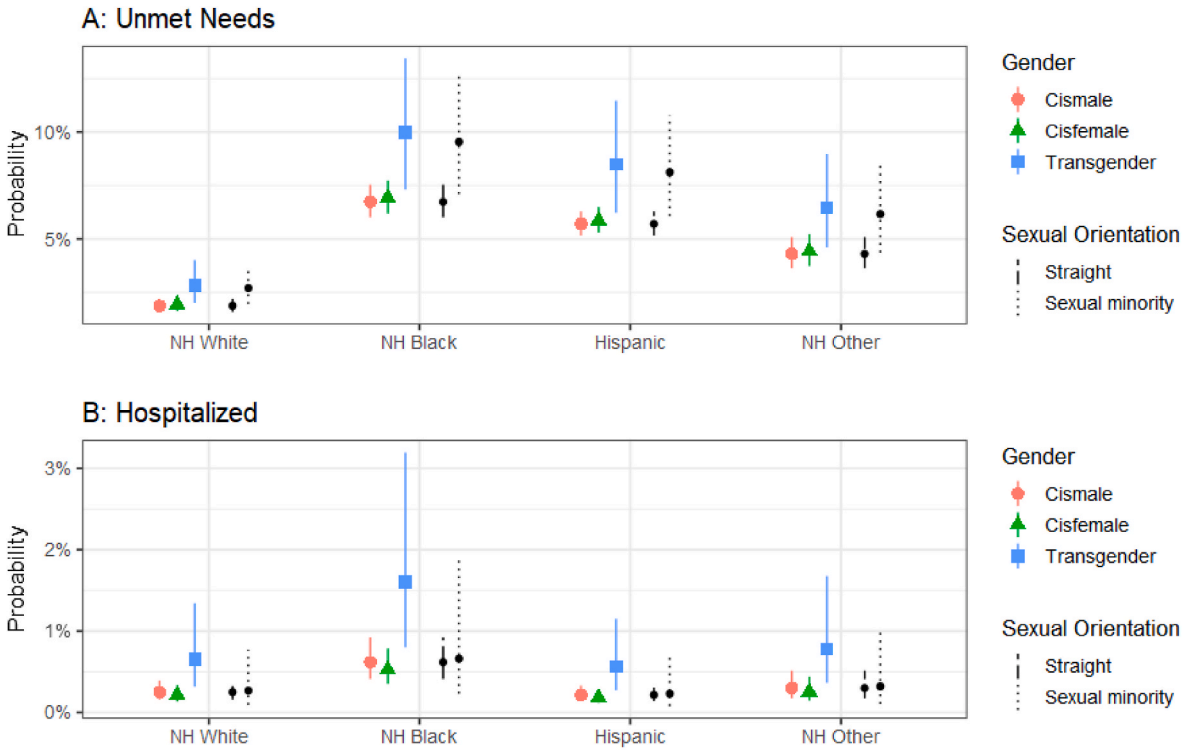
The models also largely corroborate the hypothesized associations between the socio-demographic mediators and the outcomes. For unmet needs, being younger—but more precisely a non-adult (CI = 1.9–3.3) or an adult in late 30s to early 40s (OR >1 for slope age 18–39, OR <1 for slope age 40+), chronically ill (CI = 1.3–1.6), obese (CI = 1.1–1.4), unemployed (CI = 1.0–1.3), an essential worker (CI = 1.1–1.5) or living in larger households (CI = 1.0–1.1 for household size <10) all prove risk factors. As for hospitalization, chronic illness (CI = 1.5–2.4) and unemployment (CI = 1.6–2.9) are significant indicators, whereas obesity (CI = 1~1.7) and living in 3 or more person households (CI = 0.9–1.8) are marginally significant ($p < 0.1$).

Fig. 3 plots predicted levels of categorical disparities (see S3 for data), adopting a multidimensional approach that simultaneously considers race-ethnicity and gender-sexuality. Panel A reveals stark racial-ethnic disparities even after considering gender and sexual identities and covariates. White participants, regardless of gender identity and sexual orientation, have noticeably lower expected risk of unmet needs than racial-ethnic minority participants. Within each race-ethnicity, gender and sexual minority participants are also subject to higher probabilities of unmet needs than cisgender and straight participants, with the difference being more obvious for Black and Hispanic persons. Panel B, on other hand, reiterates the health disadvantages of Black and transgender individuals, showing Black transgender individuals as having the highest hospitalization risk across all sub-groups.



Note: 95% Confidence intervals. * p < 0.05, ** p < 0.01, *** p < 0.001. Data source: CICT data of positive COVID-19 cases in Chicago who were interviewed between Sep 16, 2020, and Jan 13, 2022.Sample size remains 50,846 across models after multiple imputation.The predictors for age and household size variables in Models 1 to 3 are generated from linear piecewise functions for better data fit. For example, the coefficient for Slope age (<18 years) is the effect of being one year older on the odds of unmet needs for those younger than 18.

Fig. 2. Logistic regressions predicting unmet needs and hospitalization among COVID-19 positive cases.



Note: Predictions are based respectively on Models 3 and 6, holding all covariates at their mean (continuous) or proportion (categorical) values.

Fig. 3. Predicted levels of intergroup disparities intersecting race-ethnicity with gender and sexual orientation.

4.3. Mediation analysis

Table 2 presents KHB decomposition results. The analysis includes groups where disparities were found and mediator predictors that were significant at 0.1 level or lower in logistic models. For all columns except sexual minority, we focus on positive coefficients and percentages, which indicate factors that contribute to categorical disparities. Negative estimates, meanwhile, deserve particular attention for the sexual minority column since these factors may explain why sexual minority disparities were detected only after the addition of covariates. We also provide a visualized summary of results in Fig. 4.

About 10%–15% of racial-ethnic disparities in unmet needs are explained through mediation (Columns 1–3). Being a non-adult contracting COVID-19, chronic conditions, obesity, unemployment and larger household size are shared factors that induced racial-ethnic disparities in unmet needs for all minority groups ($p < 0.05$). For Hispanic and other-race individuals, having a higher proportion of non-adult cases ($\beta = 0.094$, $p < 0.001$) and larger households ($\beta = 0.093$, $p < 0.001$) are two prominent pathways, each explaining between 6% and 8% of their disparities against White individuals. For Black participants, having a higher share of non-adult cases ($\beta = 0.060$, $p < 0.001$) or individuals with comorbidities ($\beta = 0.054$, $p < 0.001$) respectively explains about 3.5% of their disadvantages in unmet needs; larger household size ($\beta = 0.026$, $p < 0.001$), obesity ($\beta = 0.011$, $p < 0.05$), working essential jobs ($\beta = 0.01$, $p < 0.001$) and unemployment ($\beta = 0.019$, $p < 0.001$) also contribute but each explains less than 2% of the gap.

The mediators also account for 20% of Black individuals' excessive hospitalization (Column 6). Higher risk of chronic illness ($\beta = 0.134$, $p < 0.001$) explains 11% of the differences, while higher unemployment rates ($\beta = 0.061$, $p < 0.001$) explain another 5%. Other weaker pathways include having higher proportions of obese ($\beta = 0.02$, $p < 0.05$, 2%), retired ($\beta = 0.007$, $p < 0.001$, 1%) individuals, or persons living in households with 3+ residents ($\beta = 0.028$, $p < 0.1$, 2%).

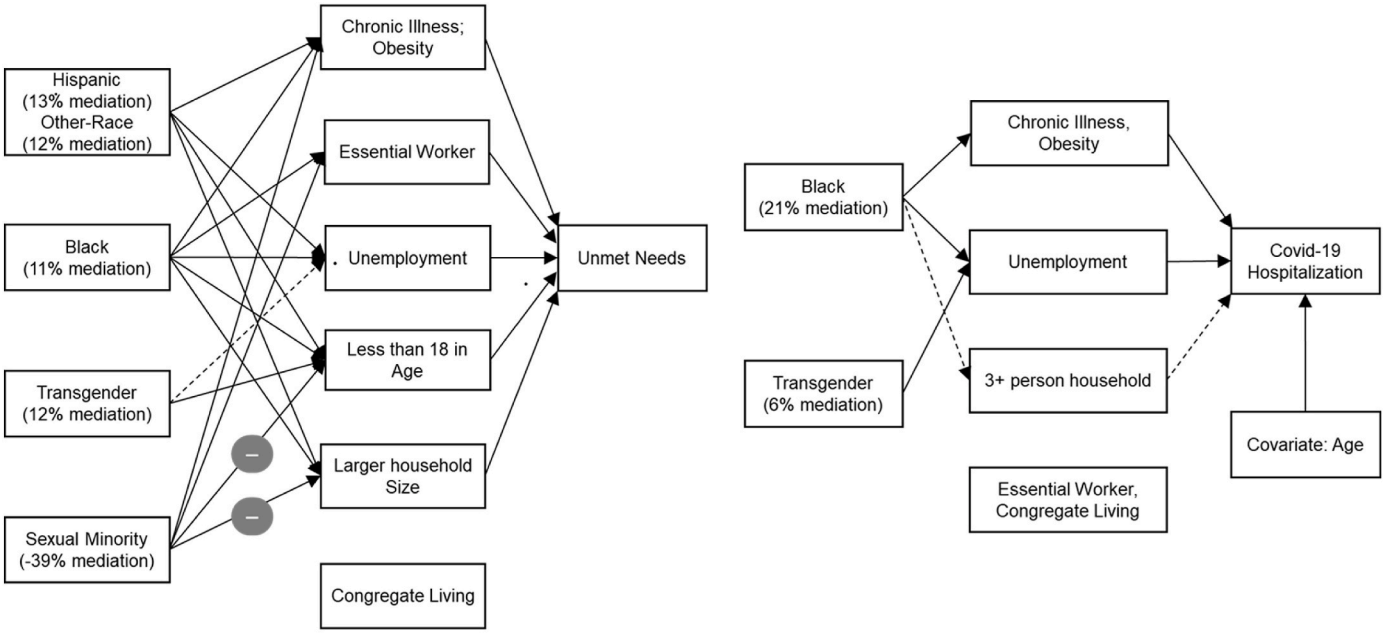
Fewer mediators apply to gender identity disparities. Regarding unmet needs (Columns 4), while all assumed pathways exert positive mediating effects, only the non-adult intercept proves significant at a 0.05 level ($\beta = 0.044$). 9% of transgender-cis male disparities in unmet needs results from the higher representation of non-adults among transgender participants. Another, marginally significant factor is transgender persons' higher unemployment rate ($\beta = 0.008$, $p < 0.1$). For hospitalization (Column 7), only 6% of the gender identity disparities relates to the mediators ($p < 0.05$), with unemployment rate as the sole significant mediator ($\beta = 0.026$, $p < 0.001$, 2.2%).

Column 5 shows that controlling for mediators elevated sexual minority disparities in unmet needs by 40%. Again, the non-adult intercept plays a key role, but in the opposite direction than for transgender or racial-ethnic groups: non-adults are rarer among sexual minority individuals, which disguised the disadvantages of sexual minority identity by 51% ($\beta = -0.158$, $p < 0.001$). Sexual minority individuals' smaller average household size served as another protective factor, suppressing the net effect of sexual minority identity by 21% ($\beta = -0.065$, $p < 0.001$). However, results indicate sexual minority individuals' higher likelihood of having chronic illness ($\beta = 0.029$, $p < 0.001$), obesity ($\beta = 0.004$, $p < 0.05$) and working in essential jobs ($\beta = 0.011$, $p < 0.05$) as *positive* contributors to their unmet needs levels, although these effects are smaller in total (10%) and overpowered by the negative mediators.

Table 2
Role of socio-demographic mediators in explaining the observed intergroup disparities.[a].

Effect of mediation	A. Unmet Needs					B. Hospitalized	
	Hispanic	NH Black	NH Other	*Trans*-gender	SexualMinority	NH Black	*Trans*-gender
Slope age (<18 years)	−0.013*	−0.009*	−0.014*	−0.004	0.022*	–	–
Slope age (18–39 years)	−0.017***	0.007*	−0.021***	−0.005	−0.006**	–	–
Slope age (40 + years)	0.002	−0.006	0.004	−0.003	0.011	–	–
Intercept age (<18 years)	0.094***	0.060***	0.093***	0.044*	−0.158***	–	–
Chronic illness	0.008***	0.054***	0.007*	0.008	0.029***	0.134***	0.022
Obesity	0.007*	0.011*	0.004*	0.003	0.004*	0.020*	0.005
Retired (ref: employed)	0.003	−0.004	0.001	−0.001	0.006	0.007*	0.003
Student (ref: employed)	−0.011***	−0.005*	−0.009***	−0.008	0.020**	0.006	0.007
Unemployed (ref: employed)	0.018***	0.019**	0.015**	0.008	−0.005	0.061***	0.026*
Essential worker	−0.001	0.010***	−0.001	−0.006	0.011*	–	–
Slope household size (<10)	0.090***	0.026***	0.083***	0.007	−0.065***	–	–
Slope household size (10+)	−0.002	0.006	−0.006	0.014	0.001	–	–
2 person household (ref: live alone)	–	–	–	–	–	−0.004	−0.001
3+ person household (ref: live alone)	–	–	–	–	–	0.028	0.007
Total mediation effects	**0.179*** **	**0.176*** **	**0.129*** **	**0.064***	**−0.121****	**0.140****	**0.070***
Percentage of mediation (%)							
Slope age (<18 years)	−0.9	−0.5	−1.2	−0.9	7.0	–	–
Slope age (18–39 years)	−1.3	0.5	−1.8	−1.0	−1.8	–	–
Slope age (40 + years)	0.2	−0.3	0.3	−0.5	3.6	–	–
Intercept age (<18 years)	6.9	3.5	7.9	8.9	−50.8	–	–
Chronic illness	0.6	3.3	0.6	1.7	9.3	11.2	1.9
Obesity	0.5	0.7	0.4	0.6	1.2	1.7	0.5
Retired (ref: employed)	0.3	−0.2	1.2	−0.2	1.8	0.6	0.3
Student (ref: employed)	−0.8	−0.3	−6.9	−1.6	6.5	0.5	0.6
Unemployed (ref: employed)	1.3	1.1	1.3	1.6	−1.6	5.1	2.2
Essential worker	0.0	0.6	−0.1	−1.3	3.7	–	–
Slope household size (<10)	6.6	1.5	7.1	1.4	−21.1	–	–
Slope household size (10+)	−0.1	0.3	−0.5	2.8	0.4	–	–
2 person household (ref: live alone)	–	–	–	–	–	−0.4	−0.1
3+ person household (ref: live alone)	–	–	–	–	–	2.4	0.6
Total mediation percentage (%)	**13.2**	**10.6**	**11.6**	**11.6**	**−39.0**	**20.9**	**6.1**

a. *p < 0.05, **p < 0.001, ***p < 0.0001. N = 399,29 using the missing indicator method for categorical variables. Reference groups: NH White, cis male, and straight. The group columns in the table include categories that exhibited differences in outcomes from the reference groups (Models 3 and 6) to which the decomposition analyses were applied. For example, disparities for unmet needs were detected for more groups than hospitalization disparities, hence the fewer columns for the latter outcome.



Note: Solid arrows represent significant paths (p<0.05). Dashed arrows depict marginally significant (p<0.1) paths. Arrows with a negative sign depict negative associations. Rectangles without arrow connections are hypothesized mediators that were not tested in the mediation models due to their lack of association with the outcomes in logistic models.

Fig. 4. Diagram summary of mediator effects.

5. Summary and discussions

This study documented and explored explanations for categorical inequalities in COVID-19-related adverse outcomes. It goes beyond previous research by simultaneously examining multiple group divisions (race-ethnicity, gender identity, and sexual orientation) and multiple outcomes (unmet resource needs and hospitalization), and by formally modeling the mediating roles of socio-demographic characteristics in accounting for the disparities.

For both outcomes, we found strong evidence of racial-ethnic and gender minority disparities among positive COVID-19 cases in Chicago. Adjusting for covariates including age structure, underlying health, work and living conditions, the odds of unmet needs were respectively about 4, 3, and 2.5 times as high among Black, Hispanic, and other-race individuals than White individuals, and Black participants were also 2.5 times as likely to be hospitalized. Meanwhile, transgender individuals were 50% more likely to have unmet needs than cisgender participants and 2.5 times more prone to hospitalization after controlling for covariates. By contrast, no sexual minority disparities were discerned regarding hospitalization, but results were subtle on unmet needs. Sexual minority and straight individuals had similar levels of unmet needs in raw comparisons; yet after adding covariates in multivariate analyses, sexual minority identity became associated with a 50% increase in the odds of unmet needs, which is driven by the older age structure and smaller household size of this group. We concluded these patterns with a graphic analysis that plots the combined effects of belonging to a racial-ethnic and gender-sexuality group, which underscored the distinctive advantages of White individuals for reduced unmet needs and the particular vulnerabilities of transgender Black participants in severe illness.

As for mediating pathways, Black, Hispanic, and other-race individuals had higher rates of younger—particularly non-adult—cases, chronic illness, obesity, unemployment, and larger household sizes, which collectively explained about 10–15% of their higher levels of unmet needs than White individuals. For Black individuals, higher likelihood of working in essential jobs is an additional pathway for unmet needs, whereas chronic illness, obesity, unemployment and living in larger households drove their risk of hospitalization by 20%.

As for gender disparities, significant pathways for unmet needs differences (10% explained) included transgenders' having a higher share of non-adult cases and unemployed individuals, while unemployment was the only significant mediator (6% explained) for hospitalization differentials.

Finally, sexual minority individuals were protected by their age composition (i.e., lower representation of non-adult cases) and smaller household size, which together suppressed the association between sexual minority identity and unmet needs by 70%. But higher rates of essential working, chronic illness, and obesity did also positively increase their unmet needs levels relative to straight individuals (15% explained).

Our findings enrich current literature in several ways. First, disparities appeared to affect more groups and at greater magnitudes when measured in terms of unmet resource needs than hospitalization. While it is possible that this was due to the rarer nature of severe COVID-19, this pattern nonetheless suggests the import of social resource inequalities as an outcome per se in the study of pandemic influences. An extensive literature has indeed documented either the "health-" or "wealth-" pandemic consequences for minority communities (Griffin et al., 2023), and our results make a strong case for such discussions by showing how physical health disparities can be a more conservative—and resource needs a more exhaustive—way of probing structural inequalities vis-à-vis the pandemic.

Second, through larger-scale and holistic assessments of gender and sexual minority disparities during the pandemic, we pointed to the specific vulnerabilities of transgender communities and the complex mechanisms whereby gender and sexual minority individuals' disadvantages were generated. Descriptively, our finding corroborates Nowaskie and Roesler's (2022) small-sample study that found gender minority individuals to experience worsening outcomes across more dimensions than sexual minority individuals.

But the mediating analyses clarified how, on one hand, relative to the general population, gender *and* sexual minority individuals share certain

constraining conditions including higher chronic illness burden and labor market exclusion (e.g., unemployment or essential worker status). On other hand, important differences also exist between these groups in age structure (more non-adults among transgender cases), household composition (smaller households among sexual minorities), and general physical health (hospitalization risk for transgender individuals), which partially explained their differential levels and types of hardships. More research is needed to interpret these findings. We speculate that the age-related findings may stem from the typically earlier development of gender identities in childhood and adolescence than sexual identity (Boskey, 2014). Also, transgender persons have health risks and mental stressors relating to gender-affirming care as well as HIV risk not lower than gay men (Bockting et al., 2005; Reisner et al., 2014), which possibly induces their higher rate of severe COVID-19 and worse general health. Moreover, the unexpected findings around sexual minority individuals and unmet needs also invite further research. For example, given that the suppression effects of sexual minority disadvantages were attributable to compositional differences in age and household size, to what extent are sexual minority individuals more protected from COVID-19 repercussions than racial-ethnic and gender minority groups? Relatedly, future research may wish to not only consider gender and sexual identities as classifying criteria, but also address sociodemographic variations within sexual and gender minority populations.

Third and more generally, the decomposition results revealed insights about inequality mechanisms that were previously neglected in the literature. While we provide confirmatory evidence on the roles of various social determinants of health (SDH) in creating categorical inequalities, our approach illustrates the analytic leverage gained by distinguishing correlation from mediation and by quantifying the contribution of respective mediators. An important example is that transgender individuals had higher prevalence of chronic illness and obesity, but these conditions did not significantly explain their gaps against cisgender persons in either outcome. Similarly, many studies looked to working conditions (e.g., essential worker, unemployment) to explain racial-ethnic disparities during the pandemic, with some finding them relevance (Dalsania et al., 2022; Griffin et al., 2023) and others that do not (Lee et al., 2022). Yet we established that differences in unemployment rate do matter in statistical testing but the magnitude of its explanatory power was also quite small, explaining between 1 and 5% of the observed disparities.

On top of this, the decomposition showed that minority groups' younger age structure, more specifically the proportion of non-adult cases, played a more prominent role in explaining disparities in unmet needs for all groups. While the hardship of young persons and families with children was occasionally discussed in media and policy reports, this finding calls on researchers to take this theme more seriously in scholarly inquiries. On another plane, the finding here also resonates with Griffin et al.'s (2023) recent work that explored age as an essential covariate in dissecting racial disparities in COVID-19 mortality, and the broader tradition in demography that foregrounds population composition as a key variable in analyzing social processes.

Finally, we emphasize the limited role of our pathway variables in explaining observed disparities. Although many of our socio-demographic mediators emerge as valid mechanisms, about 80–90% of the disparities remained unexplained in most cases. This calls for research into other, potentially more crucial mechanisms for explaining categorical disparities. For instance, systematic racism may not manifest only in terms of socioeconomic status, but also with respect to neighborhood environment, social connections, overt and covert discrimination, and chronic stress and anxiety (Chandra & Skinner, 2003; Dressler et al., 2005; Himmelstein et al., 2015). For gender and sexual minority disparities, the stigma process is often associated with perceived prejudice and ostracism, mental health struggles, and healthcare access deprivation (Drabble and Eliason. 2021; Reisner et al., 2014). We did not have the relevant data to test these mechanisms, leaving for future research to investigate these possibilities.

Our study has several limitations. First, as already noted, our data did not contain more contextual or individual-level variables that allows to further unravel explanatory pathways for each axis of inequality. For instance, measures on residential location, personal networks, health insurance, and perceived discrimination may all be key to disentangling the sources of observed inequalities. Second, missing data were substantial for the optional sexual orientation question in the CICT survey. While we used alternative measures to triangulate our results, it is not possible to empirically verify that one correctly handled missingness (Little & Rubin, 2019). Third, we could not capture gender or sexual identity with a finer classification due to data limitations (see Methods), but differences from *within* transgender and sexual minority communities deserve attention and future research. For instance, transgender men and gender-nonconforming individuals appear on average to have poorer health outcomes than transgender women (Lagos, 2018), whereas gay men and lesbian women also differ in the specific type of health concerns they experience (Conron et al., 2010). Fourth, given the small number of individuals who reported having specific type of need (see S3), we did not explore the exact needs individual groups are likely to report. Finally, our analyses focused on Chicago and are not nationally representative. While the results here provide reference points to other urban municipalities with similar demographics and disparities (Ruprecht, Wang, Johnson, Xu, & Felt, 2021), more evidence from other regions is needed to test for the generalizability of our findings.

These limitations notwithstanding, our study threw light on the emergence, magnitude, and processes of disparities during the COVID-19 pandemic. The findings extend the scholarship on gender and sexual minority disadvantages and the role of socio-demographic determinants as deriving health inequalities. With the conclusion of the COVID-19 public health emergency, these results also have ongoing policy implications for issues like long COVID (Khullar et al., 2023) and the unequal pace of economic recovery across social groups. We welcome future research with richer data and innovative methods to further our understanding of the intertwinement between social identity, resources, and health.

Author statement

Xuewen Yan: Conceptualization, Methodology, Analysis, Writing. John A. Schneider: Conceptualization, Methodology, Writing - Review & Editing, Supervision, Funding acquisition. Laxmi Modali: Data Curation, Methodology, Writing - Review & Editing, Validation. Colin Korban: Data Curation, Methodology, Writing - Review & Editing, Validation. Irina Tabidze: Data Curation, Writing - Review & Editing, Validation, Project administration.

Ethical approval

This study was approved by the IRB at City of Chicago, Chicago Department of Health.

Funding sources

The project is funded by NIDA (grant numbers: UG1DA050066, U2C DA050098). The funding recipient is the University of Chicago. The authors declare no conflict of interest.

Data availability

The authors do not have permission to share data.

Acknowledgements

This study was funded by National Institute on Drug Abuse (UG1DA050066, U2C DA050098). The authors thank Tianyao Qu, Jamie Budnick, Benjamin Cornwell, David Kern and Dawn Broussard,

for their encouragement and valuable feedback on the project. We also thank Ashley Becht, Patrick Stonehouse, Nilsa Irizarry for providing clarification on certain CICT protocols.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2023.101474.

References

Ali, S. H., Tozan, Y., Jones, A. M., Foreman, J., Capasso, A., & DiClemente, R. J. (2021). Regional and socioeconomic predictors of perceived ability to access coronavirus testing in the United States. *Annals of Epidemiology, 58*, 7–14.

Bates, N., García Trejo, Y. A., & Vines, M. (2019). Are sexual minorities hard-to-survey? Insights from the 2020 census barriers, attitudes, and motivators study (CBAMS) survey. *Journal of Official Statistics, 35*(4), 709–729.

Bockting, W., Huang, C.-Y., Ding, H., Robinson, B. bean, & Rosser, B. R. S. (2005). Are transgender persons at higher risk for HIV than other sexual minorities? *International Journal of Transgenderism, 8*(2–3), 123–131.

Boskey, E. R. (2014). Understanding transgender identity development in childhood and adolescence. *American Journal of Sexuality Education, 9*(4), 445–463.

Census Bureau. (2016). *America's families and living arrangements: 2016*. https://www.census.gov/data/tables/2016/demo/families/cps-2016.html.

Chandra, A., & Skinner, J. (2003). *Geography and racial health disparities (No. 9513)*. National Bureau of Economic Research.

City of Chicago. (2022). In *Chicago COVID dashboard*. August 24 https://www.chicago.gov/city/en/sites/covid-19/home/covid-dashboard.html. (Accessed 28 March 2023).

Clouston, S. A. P., & Link, B. G. (2021). A retrospective on fundamental cause theory: State of the literature and goals for the future. *Annual Review of Sociology, 47*(1), 131–156.

Collins, P. H. (1990). *Black feminist thought: Knowledge, consciousness, and the politics of empowerment*. Routledge ([1990]2022).

Conron, K. J., Mimiaga, M. J., & Landers, S. J. (2010). A population-based study of sexual orientation identity and gender differences in adult health. *American Journal of Public Health, 100*(10), 1953–1960.

Couch, K. A., Fairlie, R. W., & Xu, H. (2020). Early evidence of the impacts of COVID-19 on minority unemployment. *Journal of Public Economics*, 192.

Crozet, M. (2022). *Young workers have been hit hardest by COVID fallout, says UN labour agency*. UN News. August 11 https://news.un.org/en/story/2022/08/1124432.

Dalsania, A. K., Fastiggi, M. J., Kahlam, A., Shah, R., Patel, K., Shiau, S., Rokicki, S., & DallaPiazza, M. (2022). The relationship between social determinants of health and racial disparities in COVID-19 mortality. *Journal of Racial and Ethnic Health Disparities, 9*(1), 288–295.

Daly, M., Sutin, A. R., & Robinson, E. (2022). Longitudinal changes in mental health and the COVID-19 pandemic: Evidence from the UK household longitudinal study. *Psychological Medicine, 52*(13), 2549–2558.

Drabble, L. A., & Eliason, M. J. (2021). Introduction to special issue: Impacts of the COVID-19 pandemic on LGBTQ+ health and well-being. *Journal of Homosexuality, 68*(4), 545–559.

Dressler, W. W., Oths, K. S., & Gravlee, C. C. (2005). Race and ethnicity in public health research: Models to explain health disparities. *Annual Review of Anthropology, 34*(1), 231–252.

Felt, D., Xu, J., Floresca, Y. B., Fernandez, E. S., Korpak, A. K., Phillips, G., Wang, X., Curry, C. W., & Beach, L. B. (2023). Instability in housing and medical care access: The inequitable impacts of the COVID-19 pandemic on U.S. Transgender populations. *Transgender Health, 8*(1), 74–83.

Fielding-Miller, R. K., Sundaram, M. E., & Brouwer, K. (2020). Social determinants of COVID-19 mortality at the county level. *PLoS One, 15*(10).

Folk, J. (2022). Interview with marci bowers. In *What is a woman? [Film], the daily wire*.

Gillies, C. L., & Rowlands, A. V. (2022). Association between household size and COVID-19: A UK biobank observational study. *Journal of the Royal Society of Medicine, 115*(4), 138–144.

Griffin, C., Block, R., Jr., Silverman, J. D., Croad, J., & Lennon, R. P. (2023). Race, employment, and the pandemic: An exploration of covariate explanations of COVID-19 case fatality rate variance. *PLoS One, 18*(2).

Harari, L., & Lee, C. (2021). Intersectionality in quantitative health disparities research: A systematic review of challenges and limitations in empirical studies. *Social Science & Medicine, 277*, Article 113876.

Hardy, B. L., & Logan, T. D. (2020). *Racial economic inequality amid the COVID-19 crisis*. The Hamilton Project.

Harrell, F. E. (2001). *Regression modeling strategies*. New York: Springer.

Heslin, K. C., & Hall, J. E. (2021). Sexual orientation disparities in risk factors for adverse COVID-19-related outcomes. *Morbidity and Mortality Weekly Report, 70*(5), 149–154.

Himmelstein, M. S., Young, D. M., Sanchez, D. T., & Jackson, J. S. (2015). Vigilance in the discrimination-stress model for Black Americans. *Psychology and Health, 30*(3), 253–267.

Karlson, K. B., Holm, A., & Breen, R. (2012). Comparing regression coefficients between same-sample nested models using logit and probit: A new method. *Sociological Methodology, 42*(1), 286–313.

Karmakar, M., Lantz, P. M., & Tipirneni, R. (2021). Association of social and demographic factors with COVID-19 incidence and death rates in the US. *JAMA Network Open, 4*(1).

Khullar, D., Zhang, Y., Zang, C., Xu, Z., Wang, F., Weiner, M. G., et al. (2023). Racial/ethnic disparities in post-acute sequelae of SARS-CoV-2 infection in New York. *Journal of General Internal Medicine, 1–10*.

Lagos, D. (2018). Looking at population health beyond "male" and "female": Implications of transgender identity and gender nonconformity for population health. *Demography, 55*(6), 2097–2117.

Lee, H., Andrasfay, T., Riley, A., Wu, Q., & Crimmins, E. (2022). Do social determinants of health explain racial/ethnic disparities in COVID-19 infection? *Social Science & Medicine, 306*.

Lee, S., Fredriksen-Goldsen, K. I., McClain, C., Kim, H.-J., & Suzer-Gurtekin, Z. T. (2018). Are sexual minorities less likely to participate in surveys? An examination of proxy nonresponse measures and associated biases with sexual orientation in a population-based health survey. *Field Methods, 30*(3), 208–224.

Little, R. J. A., & Rubin, D. B. (2019). *Statistical analysis with missing data*. John Wiley & Sons.

Martino, R. J., Krause, K. D., Griffin, M., LoSchiavo, C., Comer-Carruthers, C., & Halkitis, P. N. (2022). Employment loss as a result of COVID-19: A nationwide survey at the onset of COVID-19 in US LGBTQ+ populations. *Sexuality Research and Social Policy: Journal of NSRC: SR & SP, 19*(4), 1855–1866.

McGowan, V. J., & Bambra, C. (2022). COVID-19 mortality and deprivation: Pandemic, syndemic, and endemic health inequalities. *The Lancet Public Health, 7*(11).

Mize, T. D., Kaufman, G., & Petts, R. J. (2021). Visualizing shifts in gendered parenting attitudes during COVID-19. *Socius, 7*.

Muñoz-Price, L. Silvia, Nattinger, Ann B., Rivera, Frida, Hanson, Ryan, Gmehlin, Cameron G., Perez, Adriana, Singh, Siddhartha, Buchan, Blake W., Ledeboer, Nathan A., & Pezzin, Liliana E. (2020). Racial disparities in incidence and outcomes among patients with COVID-19. *JAMA Network Open, 3*(9).

Nowaskie, D. Z., & Roesler, A. C. (2022). The impact of COVID-19 on the LGBTQ+ community: Comparisons between cisgender, heterosexual people, cisgender sexual minority people, and gender minority people. *Psychiatry Research, 309*.

Ormiston, C. K., & Williams, F. (2022). LGBTQ youth mental health during COVID-19: Unmet needs in public health and policy. *The Lancet, 399*(10324), 501–503.

Petersen, R., Pan, L., & Blanck, H. M. (2019). Racial and ethnic disparities in adult obesity in the United States: CDC's tracking to inform state and local action. *Preventing Chronic Disease, 16*.

Pew Research Center. (2022). Americans' complex views on gender identity and transgender issues. June 28 https://www.pewresearch.org/social-trends/2022/06/28/americans-complex-views-on-gender-identity-and-transgender-issues/.

Phillips, G., Ii, Xu, J., Ruprecht, M. M., Costa, D., Felt, D., Wang, X., Glenn, E. E., & Beach, L. B. (2021). Associations with COVID-19 symptoms, prevention interest, and testing among sexual and gender minority adults in a diverse national sample. *LGBT Health, 8*(5), 322–329.

Reisner, S. L., White, J. M., Bradford, J. B., & Mimiaga, M. J. (2014). Transgender health disparities: Comparing full cohort and nested matched-pair study designs in a community health center. *LGBT Health, 1*(3), 177–184.

Reitsma, M. B., Goldhaber-Fiebert, J. D., & Salomon, J. A. (2021). Quantifying and benchmarking disparities in COVID-19 vaccination rates by race and ethnicity. *JAMA Network Open, 4*(10).

Rogers, T. N., Rogers, C. R., VanSant-Webb, E., Gu, L. Y., Yan, B., & Qeadan, F. (2020). Racial disparities in COVID-19 mortality among essential workers in the United States. *World Medical & Health Policy, 12*(3), 311–327.

Ruprecht, M. M., Wang, X., Johnson, A. K., Xu, J., & Felt, D. (2021). Evidence of social and structural COVID-19 disparities by sexual orientation, gender identity, and race/ethnicity in an urban environment. *Journal of Urban Health, 98*(1), 27–40.

Saenz, R., & Sparks, C. (2020). *The inequities of job loss and recovery amid the COVID-19 pandemic*. https://doi.org/10.34051/p/2021.3

Sampson, R. J. (2012). *Great American city: Chicago and the enduring neighborhood effect*. University of Chicago Press.

Selden, T. M., & Berdahl, T. A. (2020). COVID-19 and racial/ethnic disparities in health risk, employment, and household composition. *Health Affairs, 39*(9), 1624–1632.

Servick, K. (2020). 'Huge hole' in COVID-19 testing data makes it harder to study racial disparities. *Science*. https://www.science.org/content/article/huge-hole-covid-19-testing-data-makes-it-harder-study-racial-disparities.

Settles, I. H., & Buchanan, N. T. (2014). Multiple groups, multiple identities, and intersectionality. *The Oxford Handbook of Multicultural Identity, 543*, 160–180.

Sperrin, M., & Martin, G. P. (2020). Multiple imputation with missing indicators as proxies for unmeasured variables: Simulation study. *BMC Medical Research Methodology, 20*(1), 185.

Thomeer, M. B., Moody, M. D., & Yahirun, J. (2022). Racial and ethnic disparities in mental health and mental health care during the COVID-19 pandemic. *Journal of Racial and Ethnic Health Disparities*, 1–16.

Vargas, S. M., Huey, S. J., & Miranda, J. (2020). A critical review of current evidence on multiple types of discrimination and mental health. *American Journal of Orthopsychiatry, 90*(3), 374–390.

Vedovato, G. M., Ali, S. H., Lowery, C. M., & Trude, A. C. B. (2022). Giving families a voice for equitable healthy food access in the wake of online grocery shopping. *Nutrients, 14*(20).

Weissbourd, R., Batanova, M., Lovison, V., & Torres, E. (2022). *Loneliness in America. Making caring common*.

Williams Institute. (2017). Characteristics of LGBT people: United States. https://williamsinstitute.law.ucla.edu/visualization/lgbt-stats/?topic=LGBT#density.

Williams Institute. (2021). *LGBT adults in large US metropolitan areas*. Retrieved https://williamsinstitute.law.ucla.edu/publications/lgbt-us-msa/. (Accessed 17 June 2023).

Yang, J., Hu, J., & Zhu, C. (2021). Obesity aggravates COVID-19: A systematic review and meta-analysis. *Journal of Medical Virology, 93*(1), 257–261.

Yan, X., Qu, T., Sperber, N., Lu, J., Fan, M., & Cornwell, B. (2021). *Tied infections: How social connectedness to other COVID-19 patients influences illness severity*. The American Behavioral Scientist.

Zhao, X., Lynch, J. G., & Chen, Q. (2010). Reconsidering baron and kenny: Myths and truths about mediation analysis. *Journal of Consumer Research, 37*(2), 197–2.