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A novel application of interrupted time series analysis to identify the impact of a primary health care reform on intersectional inequities in avoidable hospitalizations in the adult Swedish population

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ABSTRACT

Primary health care (PHC) systems are a crucial instrument for achieving equitable population health, but there is little evidence of how PHC reforms impact equities in population health. In 2010, Sweden implemented a reform that promoted marketization and privatization of PHC. The present study uses a novel integration of intersectionality-informed and evaluative epidemiological analytical frameworks to disentangle the impact of the 2010 Swedish PHC reform on intersectional inequities in avoidable hospitalizations. The study population comprised the total Swedish population aged 18–85 years across 2001–2017, in total 129 million annual observations, for whom register data on sociodemographics and hospitalizations due to ambulatory care sensitive conditions were retrieved. Multilevel Analysis of Individual Heterogeneity and Discriminatory Analyses (MAIHDA) were run for the pre-reform (2001–2009) and post-reform (2010–2017) periods to provide a mapping of inequities. In addition, random effects estimates reflecting the discriminatory accuracy of intersectional strata were extracted from a series MAIHDAs run per year 2001–2017. The estimates were re-analyzed by Interrupted Time Series Analysis (ITSA), in order to identify the impact of the reform on measures of intersectional inequity in avoidable hospitalizations. The results point to a complex reconfiguration of social inequities following the reform. While the post-reform period showed a reduction in overall rates of avoidable hospitalizations and in age disparities, socioeconomic inequities in avoidable hospitalizations, as well as the importance of interactions between complex social positions, both increased. Socioeconomically disadvantaged groups born in the Nordic countries seem to have benefited the least from the reform. The study supports a greater attention to the potentially complex consequences that health reforms can have on inequities in health and health care, which may not be immediate apparent in conventional evaluations of either population-average outcomes, or by simple evaluations of equity impacts. Methodological approaches for evaluation of complex inequity impacts need further development.

1. Introduction

Primary health care (PHC) systems are a crucial instrument for achieving equitable population health, but are hardly designed, tailored, and evaluated with equity as a central guiding principle. Research from core, as opposed to periphery, countries, shows entrenched inequities in both PHC utilization (van Doorslaer et al., 2006), as well PHC outcomes including avoidable hospitalizations, i.e., hospitalizations due to ambulatory care sensitive conditions (ACSC) (Wallar et al., 2020). In Sweden, the setting of the present study, inequities in PHC indicators have indeed been shown according to a wide range of indicators, including employment status (Ahs et al., 2012), gender (Nyamande et al., 2020; Olsson et al., 2021) sexual orientation (Gustafsson et al., 2017), education (Nyamande et al., 2020; Olsson et al., 2021) and income (Lofqvist et al., 2014; Mosquera et al., 2017; San Sebastian et al., 2017). Of note, seemingly larger inequities in health-promoting services and PHC have been seen compared to secondary care (Mosquera et al., 2017; San Sebastian et al., 2017). This body of evidence illustrates how

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health inequities can remain widespread even in countries ranking highly on economic, social and health system equity.

The multiplicity and complexity of health inequities have been highlighted in intersectionality-oriented public health and epidemiology, which has emerged in response to need for comprehensive, precise, and effective policies for health equity (Bauer, 2014; Hankivsky et al., 2014; Kapilashrami and Hankivsky, 2018). Intersectionality is a diverse analytical framework (McCall, 2005) which emphasizes inequity as a compound phenomenon, where multiple axes of power, prestige, and equity are entangled, and jointly shape the conditions of peoples' lives, including their prospects for good health and healthcare. Growing interest in intersectionality has culminated in debates about the challenges of applying an intersectional framework in epidemiology (Bauer et al., 2021; Bauer and Scheim, 2019a; Kapilashrami and Hankivsky, 2018; Merlo, 2018). This development can be viewed as the emergence of a scientific subfield, here labelled 'intersectional epidemiology.'

Intersectionality has also been forwarded as an important concept and framework for PHC policy and clinical practice (Davy, 2011; Hankivsky et al., 2014). Epidemiologic studies within the field have, however, focused on population health outcomes (Evans and Erickson, 2019; Gustafsson et al., 2016; Wemrell et al., 2017) or behavioral risk factors (Abichahine and Veenstra, 2017; Amroussia et al., 2019; Axelsson Fisk et al., 2021), with less attention being given to key policy instruments of health system or healthcare outcomes. A handful of disparate studies report complex healthcare inequities by sexual and ethnic minority groups in the US (Hernandez and Sparks, 2020), by migration, gender, class and sexual orientation in Australia (Bastos et al., 2018), by poverty, literacy and ethnicity in Nepal (Khatri et al., 2021) and by gender and class in India (Sen and Iyer, 2012). Swedish evidence on intersectional healthcare inequities is limited to survey-based studies, which have reported horizontal inequities by gender and education in primary but not secondary care utilization (Nyamande et al., 2020), and complex patterns in unmet oral care needs according to education, income, migrant status, gender, and age (Anticona et al., 2023).

The seemingly deep-rooted and multifaceted inequities in PHC outcomes could potentially be countered by progressive health reforms. Large-scale health reforms are, however, commonly introduced without sufficient consideration for how they may impact equity. When evaluated, these reforms often show disappointing results. For example, reforms expanding health insurance in the US did not change ethnic inequalities in avoidable hospitalizations (McCormick et al., 2015) or re-admission rates (Lasser et al., 2014). A series of patient choice reforms in the UK (Miani et al., 2013) and an organizational PHC reform in Canada (Ouimet et al., 2015) were followed by stable or worsened inequities in healthcare utilization. Some examples from Latin America have showed more promising findings, on the other hand, with Brazil's expanding PHC coverage associated with reduced ethnic inequalities in ACSC mortality (Hone et al., 2017), and a comprehensive PHC program in Bogotá, Colombia, which was followed by a reduction in socioeconomic inequities in child health outcomes (Mosquera et al., 2012).

A notable example of a large-scale PHC reform took place in Sweden in 2010, with the introduction of the national Free Choice in Primary Health Care (FCPHC) reform. The reform should be viewed in the context of Sweden's long tradition of publicly financed and provided healthcare (Andersson et al., 2014; Burstrom, 2009a), guided by equity principles in public health policy (Socialdepartamentet, 2018) and healthcare legislation (Ministry of Health and Social Affairs, 2017). Since the 1990s, however, Sweden has gradually increased its market-orientation, particularly in PHC (Andersson et al., 2014). This follows the steps of, for example, neighboring Nordic countries (Miani et al., 2013), the UK (Dixon and Le Grand, 2006; Fotaki et al., 2008), and several Latin American countries (Atun et al., 2015). The FCPHC reform specifically opened up for the establishment of private healthcare providers at any location, with patients given the free choice of provider, and reimbursement to the provider following the patient, and is as such an example of marketization and privatization of welfare systems (Winblad et al., 2012). While increased competition between healthcare centers was hoped to strengthen the patients' status and improve efficiency and quality of primary care (Burstrom, 2009a), concerns over increased inequities seen in other countries with similar experiences (Dixon and Le Grand, 2006; Fotaki et al., 2008; Miani et al., 2013) were voiced in Sweden (Burstrom, 2009b; Ulrika Winblad et al., 2012). The potential conflict between individual freedom on the one hand, and equity on the other, was however an issue not systematically addressed by policymakers in the deliberations leading up to the reform (Fredriksson et al., 2013).

As summarized in a couple of reviews (Burstrom et al., 2017; Fredriksson and Isaksson, 2022), several signs of inequitable consequences have been reported, such as those relating to the location of new private health care centers (Isaksson et al., 2016), composition of patients (Isaksson et al., 2018), and PHC utilization (Beckman and Anell, 2013). Evaluations of PHC-related population impact of the reform are so far sparse, with only two recent studies, reporting no effects on avoidable hospitalizations (Dietrichson et al., 2020; Mosquera et al., 2021), but with worse outcomes in regions with long-term dominance of private providers (Mosquera et al., 2021).

Evidence of the effect of intervenable policies, which may generate, amplify or temper inequities, is a crucial contribution of intersectional epidemiology to public health (Bauer, 2014). There is, however, a global absence of studies assessing whether large-scale health reforms impact complex healthcare inequity patterns. One reason for this may be related to methodological challenges, where a gap remains between evaluative methods on the one hand, and intersectionality-informed methods on the other (Bauer et al., 2021). Public health evaluations of reforms and policies commonly employ quasi-experimental interrupted time series (ITS) design (Bernal et al., 2017), due to its strong causal support (Kontopantelis et al., 2015) and applicability for temporally distinct interventions (Kontopantelis et al., 2015). The ITS design is however used to examine intervention impact on population-average outcomes (San Sebastian et al., 2019), rather than inequities in outcomes. And while the methodological toolbox of intersectional epidemiology has increased markedly (Bauer and Scheim, 2019b; Mahendran et al., 2022a; Merlo, 2018), analytical innovations are developed for and applied to cross-sectional rather than evaluative designs. This includes the increasingly used (Multilevel) Analysis of Individual Heterogeneity and Discriminatory Accuracy (MAIHDA) approaches (Merlo, 2018), which only recently have been used as a basis for examining change in intersectional inequities (Gustafsson et al., 2022).

The present study takes its point of departure in the global lack of evidence on how large-scale health reforms impact complex inequities. The overall goal was to examine intersectional inequities in primary health care quality, as indicated by ACSC hospitalizations, before and after the 2010 FCPHC reform in Sweden. The study is based on the total Swedish population aged 18–85 years and employs a novel application of MAIHDA to an evaluative ITS design. The specific aims were:

1) To map intersectional inequities in ACSC hospitalizations before and after the reform;
2) To examine the impact of the reform on the discriminatory accuracy of intersectional strata for ACSC hospitalizations.

2. Methods

2.1. Design, population and data

Pretest-posttest and single-group interrupted time-series (ITS) designs were used. With the FCPHC reform introduced nationally on Jan 1st, 2010, the study period was divided into pre-reform period (2001–2009; 9 yearly observations), and a post-reform period (2010–2017, 8 yearly observations).

The study population included all residents in Sweden aged 18–85 years each year 2001–2017, comprising N = 129,508,939 observations

for the entire study period, with annual observations ranging between N = 7,005,299 in 2001 and N = 8,060,714 in 2014. Individual-level data were retrieved for each year from multiple registers with total population coverage, and were individually linked across registers through the Swedish Personal Identity Number. Information on hospitalization was retrieved from the National Inpatient Register of the National Board of Health and Welfare, while sociodemographic information from registers of Statistics Sweden. The study was reviewed and approved by The Regional Ethical Review Board in Umeå (Ref. no. 2017/229-31) and by the data safety committees of the register holders.

2.2. Measures

2.2.1. Outcome

The outcome comprised avoidable hospitalizations, defined as hospitalization due to ACSC. ACSC hospitalizations are considered a general indicator of PHC quality, capturing aspects such as continuity (Kao et al., 2019; van Loenen et al., 2014), accessibility (Gibson et al., 2013; Rosano et al., 2013), and resources (Gibson et al., 2013; van Loenen et al., 2014). We used the classification of ACSC diagnoses by The National Board of Health and Welfare, (Lofqvist et al., 2014; The National Board of Health and Welfare and Swedish Association of Local Authorities and Regions, 2012), covering both chronic (iron-deficiency anemia, asthma, diabetes complications, congestive heart failure, hypertension, chronic obstructive pulmonary disease, and angina) and acute (perforated/-bleeding ulcer, dehydration and gastroenteritis, convulsion and epilepsy, pelvic inflammatory disease, pyelonephritis, and ear, nose and throat infections) conditions. The binary outcome variable identified hospitalization due to any ACSC (1 = yes/0 = no) each year 2001–2017.

2.2.2. Inequity dimensions and intersectional positions

The following five indicators of inequity dimensions were used: *Age*, divided into young (18–35 years), mid-adulthood (36–64 years), and old adulthood (65–85 years); *Gender*, proxied by legal sex (woman/man); *Country of birth*, categorized into Nordic countries (Denmark, Finland, Iceland, Norway and Sweden), other core countries (US, other European Union countries, Australia) and periphery countries (other countries); *Education*, classified into compulsory, secondary or tertiary education level; and *Income*, based on disposable annual income, which was divided into low, medium, and high income, according to tertiles of the income distribution.

To operationalize *intersectional strata*, the five individual inequity dimensions were combined into a variable comprising all 162 ($3 \times 2 \times 3 \times 3 \times 3 = 162$) unique combinations of the individual inequity dimensions.

2.3. Statistical analysis

The analytical approach is summarized below, and described in detail elsewhere (see Supplementary Statistical details).

The first set of analyses aimed to provide a complete mapping of the intersectional inequalities before and after the 2010 reform (corresponding to Aim 1). Stratum-specific absolute risks of avoidable hospitalization (%) were estimated for the pre-reform and post-reform period, respectively, with 95% confidence intervals (CI). Then, three MAIHDA models (Persmark et al., 2019) were then run for the pre-reform (2001–2009) and post-reform (2010–2017) periods, respectively, with individual annual observations (level 1) nested within the 162 intersectional strata (level 2). Model 1 (simple intersectional model) was an empty random-intercept model estimating the Variance Partitioning Coefficient (VPC). The VPC (%) represents the overall clustering of avoidable hospitalizations within intersectional strata. Models 2 (partially adjusted intersectional models) comprised five models adjusting for one inequality indicator at a time, and Model 3 (intersectional interaction model) simultaneous adjustment for all indicators. Results from these models are reported as fixed-effects odds ratios (OR, with 95%CI), as well as random-effects Proportional Change in Variance (PCV). The PCV (%) quantifies how much the five inequality dimensions, individually (Models 2) and jointly (Model 3), contribute to the clustering estimated by the VPC in Model 1. A high PCV reflects that the corresponding inequity indicators contribute to clustering estimated in Model 1. In Model 3, the PCV represents the variance left unexplained after consideration of all main effects. A low PCV in Model 3, where all main effects are considered, thus captures effects potentially attributable to intersectional interaction effects. Model 3 was also used to estimate the fixed-effect Absolute Risks due to Interaction (ARI) (Persmark et al., 2019) for each of the 162 intersectional strata (percentage points (pp) with 95% confidence intervals (CI)). A positive (negative) ARI reflects a higher (lower) stratum-specific risk of hospitalization than expected.

The second set of analyses aimed to estimate the impact of the 2010 reform on intersectional inequities in avoidable hospitalization (corresponding to Aim 2). To yield annual estimates of the overall intersectional effect, a series of MAIHDA models corresponding to those above were run, but for each year 2001–2017. The VPC of Model 1, and the PCV of Models 2 and 3, were chosen as key summary estimates of the intersectional effect in ACSC hospitalizations, and were extracted for use as outcomes in a series of ITSA models (Linden, 2015). Seven ITSAs models corresponding to the MAIHDA models above, were run, with estimates reported as β coefficients with 95%CI. From the estimates, the Time*Period effect estimates the difference in the slope of the trends in the post-reform, compared to pre-reform period. This estimate thus captures the degree to which the introduction of the reform impacted intersectional inequities in ACSC hospitalizations (as indicated by VPC/PCV).

3. Results

3.1. Descriptive statistics before and after the reform

As can be seen in Table 1, compared to the pre-reform population (2001–2009), the post-reform population (2010–2017) comprised a higher proportion of older adults (23.6% in post-reform vs. 20.5% in pre-reform period), immigrants from periphery countries (8.6% vs. 5.3%), and a lower proportion of people with only compulsory education (22.2% vs. 28.0%) but a similar gender distribution. A slightly smaller percentage were hospitalized due to any ambulatory care sensitive condition (ACSC) during the post-reform period (1.0%) compared to the pre-reform period (1.1%). ACSC hospitalizations were considerably more frequent among older adults, those with only compulsory education, low income, or who were born in the Nordic countries. Men displayed a marginally higher frequency than women.

3.2. Mapping of inequities before and after the reform

The mapping of inequities in ACSC hospitalizations during the pre- and postreform periods, respectively, is reported in three steps: first, fixed-effect estimates for the individual inequality dimensions, i.e., without consideration of intersectional strata (Table 2, Models 2); second, absolute risks of hospitalization reported by intersectional strata (Fig. 1); and third, absolute interactions by intersectional strata (Fig. 2).

The magnitude of relative inequalities in hospitalizations by each inequality dimension, for the pre- and post-reform periods, respectively, are shown by fixed-effects estimates in Table 2, Models 2. As expected, age was by far the most influential indicator during both periods, albeit slightly less pronounced during the post-reform compared to the pre-reform period. In contrast, inequalities by education and income were of slightly larger magnitude in the post-than in the pre-reform period. No substantial inequalities were observed for either gender of country of birth in either period. All estimates were only minimally attenuated by mutual adjustment (Table 2, Model 3).

This preliminary analysis was expanded to consideration of

Table 1
Descriptive characteristics of the pre-reform and post reform study populations and absolute risk of avoidable hospitalization. Numbers are N with column percentages (Total) or row percentages (ACSC).

	Pre-reform period 2001–2009		Post-reform period 2010–2017	
	Total	ACSC	Total	ACSC
Total sample	65,755,892 (100%)	743,414 (1.1%)	63,753,047 (100%)	667,961 (1.0%)
Age				
Young	20,694,555 (31.5%)	54,221 (0.3%)	20,066,658 (31.5%)	54,852 (0.3%)
Mid	31,564,239 (48.0%)	220,275 (0.7%)	28,671,765 (45.0%)	155,467 (0.5%)
Old	13,497,098 (20.5%)	468,918 (3.5%)	15,014,624 (23.6%)	457,642 (3.0%)
Gender				
Woman	33,224,416 (50.5%)	355,494 (1.1%)	32,070,445 (50.3%)	329,591 (1.0%)
Man	32,531,476 (49.5%)	387,920 (1.2%)	31,682,602 (49.7%)	338,370 (1.1%)
Country				
Nordic	58,578,141 (89.1%)	681,916 (1.2%)	54,017,794 (84.7%)	598,373 (1.1%)
HIC	3,671,453 (5.6%)	37,784 (1.0%)	4,262,974 (6.7%)	37,389 (0.9%)
LMIC	3,506,298 (5.3%)	23,714 (0.7%)	5,472,279 (8.6%)	32,199 (0.6%)
Education				
Tertiary	14,726,317 (22.8%)	85,613 (0.6%)	17,217,502 (27.8%)	97,062 (0.6%)
Secondary	31,711,283 (49.1%)	278,095 (0.9%)	30,925,979 (49.9%)	279,068 (0.9%)
Compulsory	18,097,702 (28.0%)	359,622 (2.0%)	13,776,959 (22.2%)	274,120 (2.0%)
Missing	1,220,590	20,084	1,832,607	17,711
Income				
High	21,918,628 (33.3%)	153,282 (0.7%)	21,251,014 (33.3%)	121,468 (0.6%)
Mid	21,918,631 (33.3%)	244,273 (1.1%)	21,251,015 (33.3%)	197,700 (0.9%)
Low	21,918,633 (33.3%)	345,859 (1.6%)	21,251,018 (33.3%)	348,793 (1.6%)

intersectional strata. Crude absolute risks (%) of avoidable hospitalizations by intersectional stratum and study period are displayed in Fig. 1 (reported in full in Supplementary Table S1). The overall risk patterns were comparable across genders and age groups, albeit at an expectedly much higher level among the older age groups, as seen in Table 2. However, there was still a considerable heterogeneity in risk even within the oldest age group, ranging from around 1% in Nordic-born women with high education and income, to 5% among men with low income and education. When it comes to income and education, the clear gradients in risk of hospitalization seen Table 2 were present across most strata but were less pronounced and consistent among immigrant women and men, than among Nordic-born.

When it comes to difference between periods, the small population-average reduction in avoidable hospitalizations from the pre-reform to the post-reform period (from 1.1% to 1.0%, Table 1) was widespread across intersectional strata. Larger decreases were however seen in certain strata, particularly among women from periphery countries, while little change or slight increases in risk was observed among low-educated and low-income women and men born in Nordic or other core countries.

To specifically illustrate the interaction effect between intersectional strata on avoidable hospitalization, the absolute risk of interaction (ARI) per intersectional strata are illustrated in Fig. 2, for the pre- and post-reform periods (reported in full in Supplementary Table S2). The greatest variation in ARI estimates was seen across age groups, reflecting the large variation in risk between age groups (Table 2). Strata comprising individuals of old age consistently displayed significant positive ARIs in the range of 1–5% in all strata, reflecting higher risks of ACSC hospitalizations than would be expected from only considering the main effects of the individual inequality dimensions. The ARIs within this age group displayed clear gradients across education and income, with higher estimates among those of lower education and income. The two younger age groups displayed more varying patterns, comprising both positive and negative interactions but with most estimates close to zero. Several intersectional strata, all including immigrants (women or men) with high or medium income and secondary or tertiary education, also displayed negative ARI estimates, indicating a lower risk than would be expected from the combination of social positions. In addition to the observations displayed in Figs. 2 and 13 intersectional strata displayed extreme negative ARI values and, to enable a visual representation of the overall patterns for the majority of strata, the values of these strata were suppressed in Fig. 2 (but are reported in Supplementary Table S2). These strata, which displayed markedly lower risks of ACSC hospitalization than what would be expected given their intersectional position, chiefly comprised immigrant women with otherwise favorable socioeconomic conditions, and where from both periods. Specifically, 9 out of 13 strata comprised young or middle-aged immigrant women, of which the majority were of high income (8/9 strata) and tertiary (6/9 strata) education. With regard to the study periods, the overall pattern among older adults was slightly lower ARI in the post- than in the pre-reform period. No general discernible pattern was seen in the considerably lower ARI estimates of middle-aged or young adults.

3.3. Impact of reform on discriminatory accuracy of intersectional strata for ACSC hospitalizations

The impact of the 2010 reform on the discriminatory accuracy of inequality indicators and intersectional strata were assessed by random effect estimates from simple intersectional (empty) model (Model 1), partially adjusted intersectional models (Models 2), and intersectional interaction model (Model 3). The VPC and PCV estimates for the three models are first summarized for the pre- and postreform period, respectively, in Table 2, which is followed by an analysis of the pre- and postreform trends in a series of ITSAs, displayed in Table 3 and Fig. 3. The annual outcomes used in the ITSAs were VPC (Model 1) and PCV (Models 2 and 3).

The simple intersectional model (Model 1) estimated that approximately 28% of the variation of ACSC hospitalizations was clustered within intersectional strata (Table 2), with no change in trends following the introduction of the reform (Table 3, Model 1). These results show a considerable and constant degree of clustering of hospitalizations by intersectional strata before and after the reform.

The partially adjusted intersectional model (Models 2) sought to elucidate the contribution of individual inequality indicators to this clustering (Table 2, Fig. 3 and Table 3). Age was a dominant contributor across the entire period, albeit with lower contribution during the post-reform period (Table 2, pre-reform PCV = 87%, post-reform PCV = 81%) which was expressed as a decreasing trend during the pre-reform period (Table 3, Time $\beta = -0.36$ (-0.53 to -0.19)), which was significantly steeper during the post-reform period (Time*Period $\beta = -0.44$ (-0.71 to -0.17)). Education, the overall second most important contributor, displayed a numerically higher contribution in the post-reform period (Table 2, pre-reform PCV = 5.3%, post-reform PCV = 7.5%), which was expressed as a tendency to positive trend in the pre-reform period (Time $\beta = 0.16$ (-0.01 – 0.34), as well as a tendency to even steeper trend in the post-reform period (Time*Reform $\beta = 0.26$ (-0.01 – 0.53) (Table 3). Income also showed a higher contribution increasing trend in the pre-reform period (Table 2, pre-reform PCV = 2.0%, post-reform PCV = 4.1%), with positive trends in the post-reform period (Time $\beta = 0.19$ (0.05–0.33)) but which tended to flatten out slightly in the post-reform period (Time*Reform $\beta = -0.09$ (-0.31 – 0.12)). Gender and country of birth made very small contributions across the entire study periods (PCV <1%, Fig. 3). Taken together, Models 2 suggest that introduction of the reform was followed by a

Table 2
Multilevel models of avoidable hospitalizations across 162 intersectional strata before and after reform: one empty model (M 1), five partially adjusted models (M 2) and one fully adjusted model (M 3). Fixed effect estimates are Odds Ratios (95% CI) and random effects estimates are Variance Partition Coefficient (VPC, %) and Partial Coefficient of Variation (PCV, %).

Estimate	Pre-reform period (2001–2009)			Post-reform period (2010–2017)		
	M 1	M 2	M 3	M 1	M 2	M 3
Fixed effects						
Age						
Young		Ref.	Ref.		Ref.	Ref.
Mid		3.10 (2.65–3.63)	3.11 (2.80–3.45)		2.48 (2.07–2.99)	2.49 (2.22–2.78)
Old		13.70 (11.69–16.05)	13.76 (12.39–15.28)		11.43 (9.50–13.74)	11.48 (10.26–12.86)
Gender						
Woman		Ref.	Ref.		Ref.	Ref.
Man		1.04 (0.73–1.48)	1.05 (0.96–1.14)		0.99 (0.70–1.40)	1.00 (0.91–1.10)
Country						
Nordic		Ref.	Ref.		Ref.	Ref.
HIC		0.95 (0.61–1.46)	0.95 (0.86–1.05)		0.89 (0.59–1.36)	0.90 (0.80–1.00)
LMIC		1.00 (0.65–1.54)	1.01 (0.91–1.12)		0.91 (0.60–1.38)	0.91 (0.82–1.02)
Education						
Tertiary		Ref.	Ref.		Ref.	Ref.
Secondary		1.41 (0.93–2.15)	1.40 (1.27–1.56)		1.50 (1.00–2.25)	1.49 (1.34–1.67)
Compulsory		1.91 (1.25–2.92)	1.91 (1.72–2.12)		2.11 (1.40–3.16)	2.09 (1.87–2.34)
Income						
High		Ref.	Ref.		Ref.	Ref.
Mid		1.30 (0.85–2.00)	1.28 (1.16–1.43)		1.28 (0.85–1.94)	1.28 (1.15–1.44)
Low		1.47 (0.96–2.26)	1.45 (1.31–1.61)		1.74 (1.15–2.64)	1.74 (1.56–1.95)
Random effects						
VPC	28.622		2.103	27.465		2.499
VPC Age		4.897			6.623	
VPC Gender		28.615			27.465	
VPC Origin		28.615			27.427	
VPC Edu		27.521			25.948	
VPC Income		28.220			26.631	
PCV	*Ref.*		94.644	*Ref,*		93.232
PCV Age		87.159			81.268	
PCV Gender		0.033			0.001	
PCV Origin		0.034			0.190	
PCV Edu		5.308			7.462	
PCV Income		1.959			4.142	

decreased importance of age, and tendencies to increasing importance of education, when it comes to explaining the clustering of hospitalizations within intersectional strata.

The intersectional interaction models (Model 3) intended to identify the proportion of the clustering in ACSC hospitalizations that is not explained by the individual inequality indicators, and is instead attributable to intersectional interactions, as indicated by the PCV (Table 2, Table 3 and Fig. 3). The PCV reflected a high proportion of the clustering jointly explained by the main effects of the inequality dimensions but with a lower proportion in the post-reform period (Table 2, pre-reform PCV = 94.6%, post-reform PCV = 93.2%), which correspond to a higher proportion attributable to intersectional interactions in the post-reform period. In the corresponding ITSA (Table 3, Fig. 3), the PCV displayed a flat trend during the pre-reform period (Time $\beta = -0.02$ ($-0.11 - 0.07$)) and upon the introduction of the reform, little change in level (Reform $\beta = -0.35$ ($-1.05 - 0.36$). However, after the reform, a change towards negative trends during the post-reform period was seen (Time*Reform $\beta = -0.18$ (-0.32 to -0.03). This corresponds to an increased contribution of interactions between intersectional social positions to the clustering of hospitalizations by intersectional strata after the introduction of the reform in 2010.

4. Discussion

The present report illustrates a marked complexity of inequities in PHC quality, as indicated by avoidable (ACSC) hospitalizations, over the course of almost two decades in Sweden during which a major reform promoting privatization of PHC was introduced. The study proposes a novel analytical approach which is broadly applicable to impact assessments of reforms or other population-level interventions on intersectional health inequities. While the overall degree of intersectional inequities in avoidable hospitalizations remained constant across the study period, the result suggest that the reform brought about a subtle reconfiguration of the relative importance of equity dimensions. Specifically, a decreasing importance of age, and a simultaneous increasing importance of education as well as interactions between intersectional strata.

Considering the nature of the outcome – hospitalizations due to a selection of chronic and acute conditions – a dominant patterning by age, compared to the other considered inequity dimensions, was as expected. However, while the post-reform period displayed ubiquitous reductions in hospitalizations across most intersectional strata as well as decreased disparities by age, inequities by education, as well as income, were exacerbated. The results suggest that the previously demonstrated lack of a population-average reduction in avoidable hospitalizations (Dietrichson et al., 2020; Mosquera et al., 2021) may hide underlying inequities in the population impact of the reform. A shift in importance, from age to education, was also visible in the ITSA analysis of discriminatory accuracy. Taken together, these findings suggest that the reform may have led to a reduction in age differentials in PHC quality, but simultaneously increased socioeconomic inequities, and that the socioeconomic inequities tend to explain a larger share of the overall, intersectional, population patterns in avoidable hospitalizations. This inequitable impact is likely underpinned by a combination of the multiple PHC aspects of inequities documented in the wake of the Swedish FCPHC reform, e.g., concerning the localization of new health care centers, the utilization of PHC, and the 'free choice' of provider (Burstrom et al., 2017; Fredriksson and Isaksson, 2022). At a general level, the results thus confirm the long-standing concerns about inequitable consequences of the reform, as well as demonstrate that inequities may

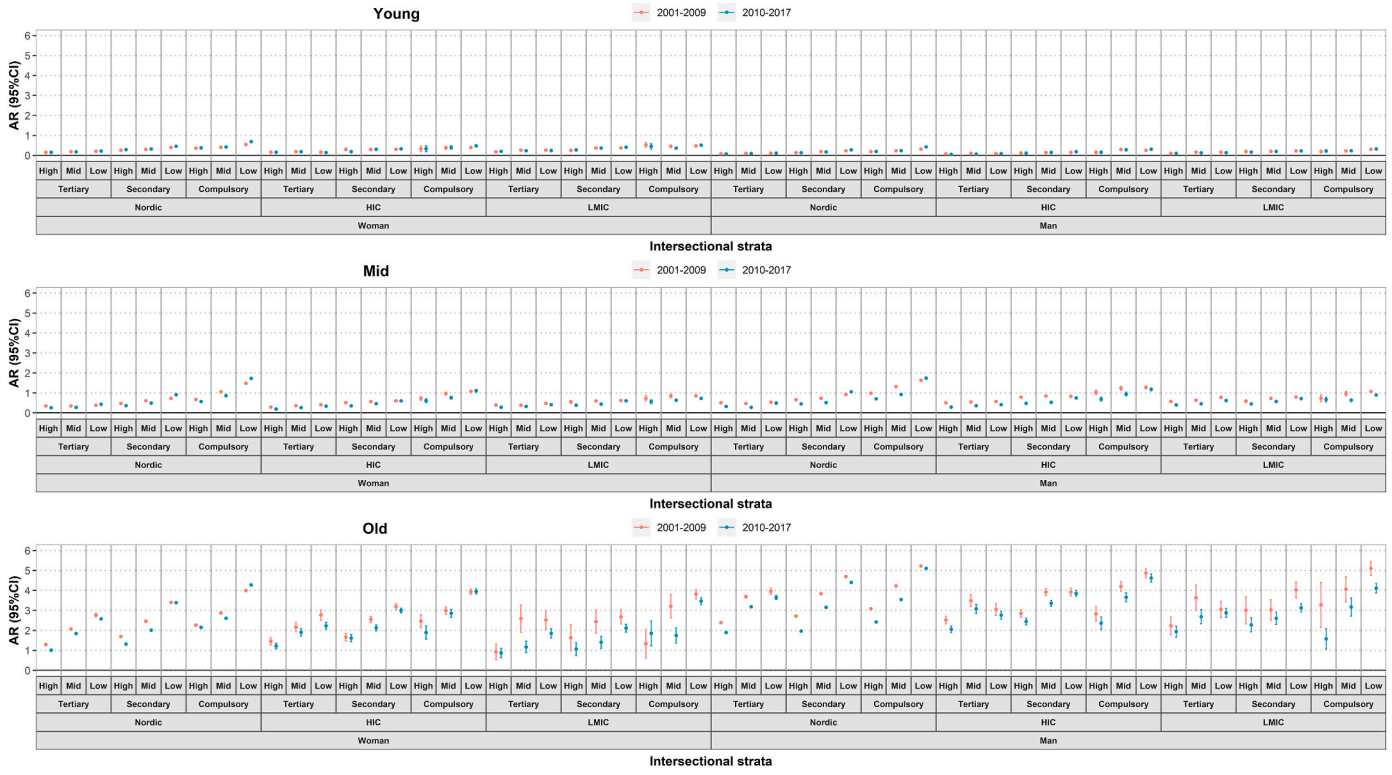

Fig. 1. Occurrence of avoidable hospitalizations in 162 intersectional strata, during the pre-reform (2001–2009) and post-reform (2010–2017) periods. Observations are reported as Absolute Risks (AR, %) with 95% confidence intervals (CI).

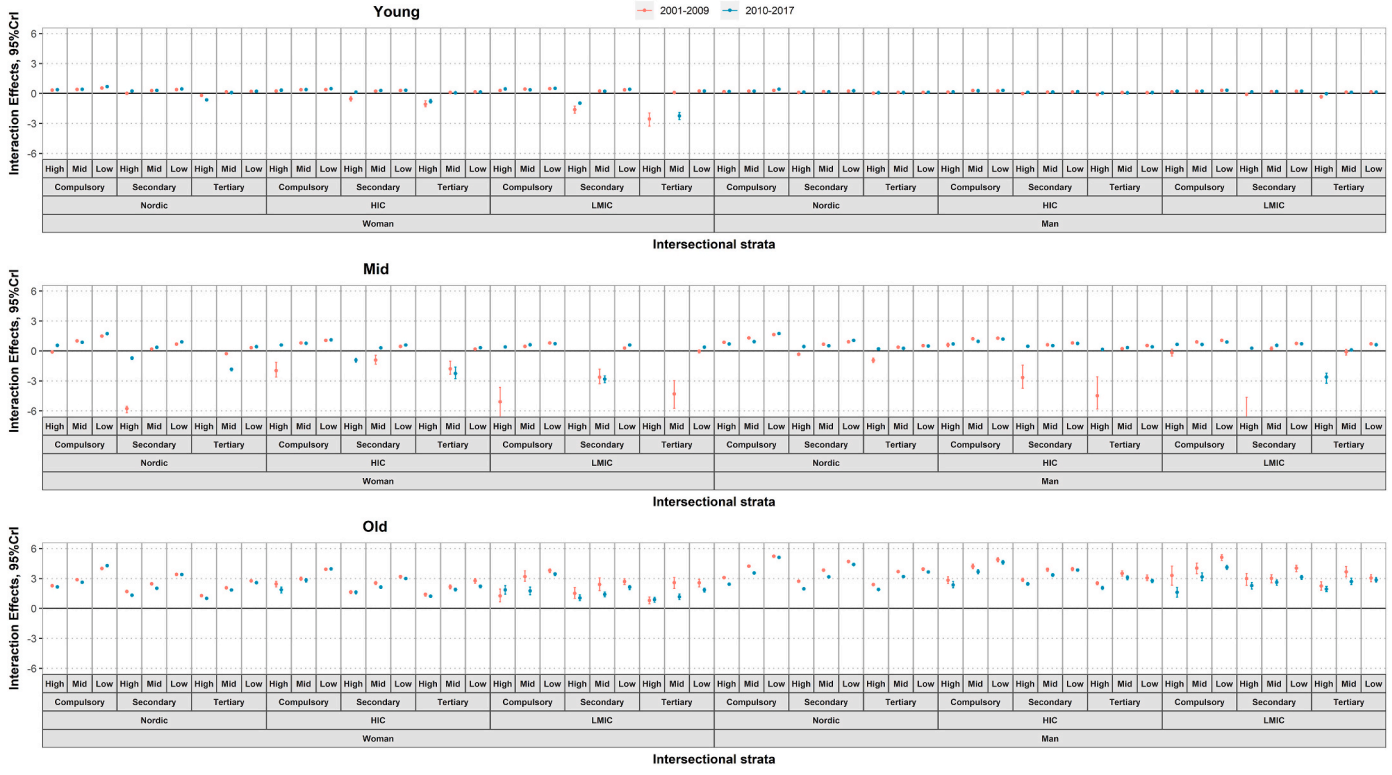

Fig. 2. Additive interaction effects of avoidable hospitalizations across 162 intersectional strata, during the pre-reform (2001–2009) and post-reform (2010–2017) periods. Observations are reported as Absolute Risk due to Interaction (ARI, percentage points) with 95% credible intervals (CrI).

Table 3
Summary of interrupted time series analysis estimating the impact of 2010 reform on intersectional inequities in avoidable hospitalizations, operationalized as variance partition coefficient (VPC, Model 1) and partial change in variation (PCV, Models 2 and 3). Numbers are regression coefficients (β) with 95% confidence intervals (CI).

Effect	Model 1	Models 2					Model 3
		Age	*Gender*	*Country*	*Education*	*Income*	
Time (Years)	−0.11 (−0.30 – 0.08)	**−0.36 (-0.53 – -0.19)**	**−0.06 (-0.09 – -0.03)**	−0.00 (−0.02 – 0.02)	0.16 (−0.01 – 0.34)	**0.19 (0.05–0.33)**	−0.02 (−0.11 – 0.07)
Reform (post- vs pre)	0.11 (−1.33 – 1.56)	−1.11 (−2.41 – 0.19)	0.14 (−0.07 – 0.35)	0.12 (−0.04 – 0.27)	−0.33 (−1.65 – 0.99)	0.98 (−0.05 – 2.01)	−0.35 (−1.05 – 0.36)
Interaction (Time*Reform)	−0.06 (−0.36 – 0.24)	**−0.44 (-0.71 – -0.17)**	**0.07 (0.02–0.11)**	0.03 (−0.01 – 0.06)	0.26 (−0.01 – 0.53)	−0.09 (−0.31 – 0.12)	**−0.18 (-0.32 – -0.03)**

be expressed even in the concrete but distal consequences of potentially preventable hospitalizations. The study therefore adds to the literature from core countries showing that health reforms often do not improve equity in PHC quality indicators (Lasser et al., 2014; McCormick et al., 2015; Miani et al., 2013; Ouimet et al., 2015).

The finding of an increasing importance of intersectional interactions after the reform are difficult to directly attribute to any specific strata, as the random effects capture the global pattern across all strata. However, considering the fixed effects, while gender and country of birth played an insubstantial direct role throughout the analyses, certain intersectional patterns were contingent on the position along these axes. Specifically, the education- and income-related gradients were more pronounced in Nordic-born strata, and socioeconomically disadvantaged Nordic-born strata were also among the few groups that did not seem to benefit from the reform. In contrast, certain groups of socioeconomically advantaged immigrant women displayed a considerably lower risk than would be expected from their intersectional positions, and women from periphery countries also benefitted from the reform, displaying the greatest reduction in risk during the post-reform period. These changing patterns following the reform may partly explain the increased importance of intersectional interactions, and specifically also suggest a complex, and unexpected, disadvantage of the reform impact for certain socioeconomically disadvantaged Nordic-, rather than foreign-born, groups. This example may reflect the intersectional process of leveraging (Sen and Iyer, 2012), where immigrant women are able to counteract social disadvantage by leveraging a favorable socioeconomic position to secure health care entitlements. These nuances may be important evidence for policymakers to counteract inequitable effects of the reform, e.g., reimbursement systems taking the composition of the population served into account, which have been implemented particularly in regions with left-wing government (U. Winblad et al., 2021).

4.1. Methodological considerations

One important methodological strength of this study is the inclusion of the total population, using high-quality Swedish registers with close-to-complete coverage. Compared to studies based on surveys or limited registers, this is expected to protect against selection bias. Moreover, it guarantees a good external validity when generalized to Sweden or similar contexts, e.g., the Nordic or Northern European countries. Nevertheless, as the overall societal and health system context, as well as the particularities of the specific health reform studied, are expected to matter greatly for the findings, generalization beyond this context should be done with caution.

The use of register data, while imposing limits on availability of information, e.g., limiting the range of inequity dimensions studied, also protects against risk of information bias which might affect self-administered surveys, e.g., recall bias. The use of ACSC hospitalizations, is established for monitoring and research purposes, and has been shown to capture multiple aspects pf PHC quality (Gibson et al., 2013; Kao et al., 2019; Rosano et al., 2013; van Loenen et al., 2014). However, the measure also contains limitations, e.g., the multifactorial and undefined causes of variation in ACSC poses challenges when it comes to interpreting it as a measure of PHC quality (Hodgson et al., 2019).

When it comes to the analysis, the study utilized a novel analytical approach which integrated the approach of MAIHDA (Merlo, 2018; Persmark et al., 2019) to the rigorous evaluative framework of ITS design and analysis (Kontopantelis et al., 2015; Linden, 2015). MAIHDA has emerged as one preferred analytical approach to study intersectional health inequities (Evans et al., 2023; Ljungman et al., 2021; Zubizarreta et al., 2022), as it focuses on contexts rather than individual characteristics, considers variation and discriminatory accuracy rather than only mean-centric measures of effect, and is able to handle a large set of intersectional strata. One drawback of the method is its intricate interpretation (Evans et al., 2020; Lizotte et al., 2020), which can be seen as a limitation especially when it comes to the applicability of the method and communication of the results, particularly in relation to policymakers and public health practitioners. This interpretational and communicative challenge, e.g., when it comes to explicating meaningful effect sizes, becomes multiplied when integrated with another analytical framework, in this study ITS design and analysis.

The ITS design relies on the counterfactual assumptions of projected trends (Haber et al., 2021), meaning that in the absence of the introduction of the reform, the trends in ACSC for all intersectional groups would have continued with the same slope as before the introduction of the reform. Considering the real-world setting of a dynamic and dispersed health system which is constantly evolving, e.g., efforts to reduce unplanned hospitalizations and readmissions, competing interventions may have contributed to misattribution of the effects to the reform. The ITS design is also susceptible to misspecified timing of the policy impact (Haber et al., 2021), e.g., a possible lag in the population impact would likely lead to underestimation of the impact. Exposure misclassification would have a similar effect. For example, while the present study examined the impact of the national introduction of the reform, certain regions had introduced similar regulations before 2010, and the practical health system change after 2010 varied greatly across regions (e.g., when it comes to new establishments of PHC centers), which is further complicated by individuals moving between regions at different points during the study period. Taken together, while this study represents an effort for estimating a reform impact on intersectional inequities in health, multiple potential sources of bias are still present, why definitive causal interpretations should be avoided. The availability of an unexposed control group would have provided further protection against bias.

In the ITSA, random effect estimates generated from MAIHDA analyses were used as outcomes. While ITSA conventionally uses measured outcomes (e.g., morbidity) rather than derived estimates as the point of departure, we would argue that, in essence, both instances represent parameter estimates (e.g., of population prevalence). Moreover, as the present study comprised a total population rather than a sample, the generated estimates could be considered close approximations to the population parameters. To limit the already considerable complexity of the analysis, specific parameters (VPC and PCV) were chosen for the

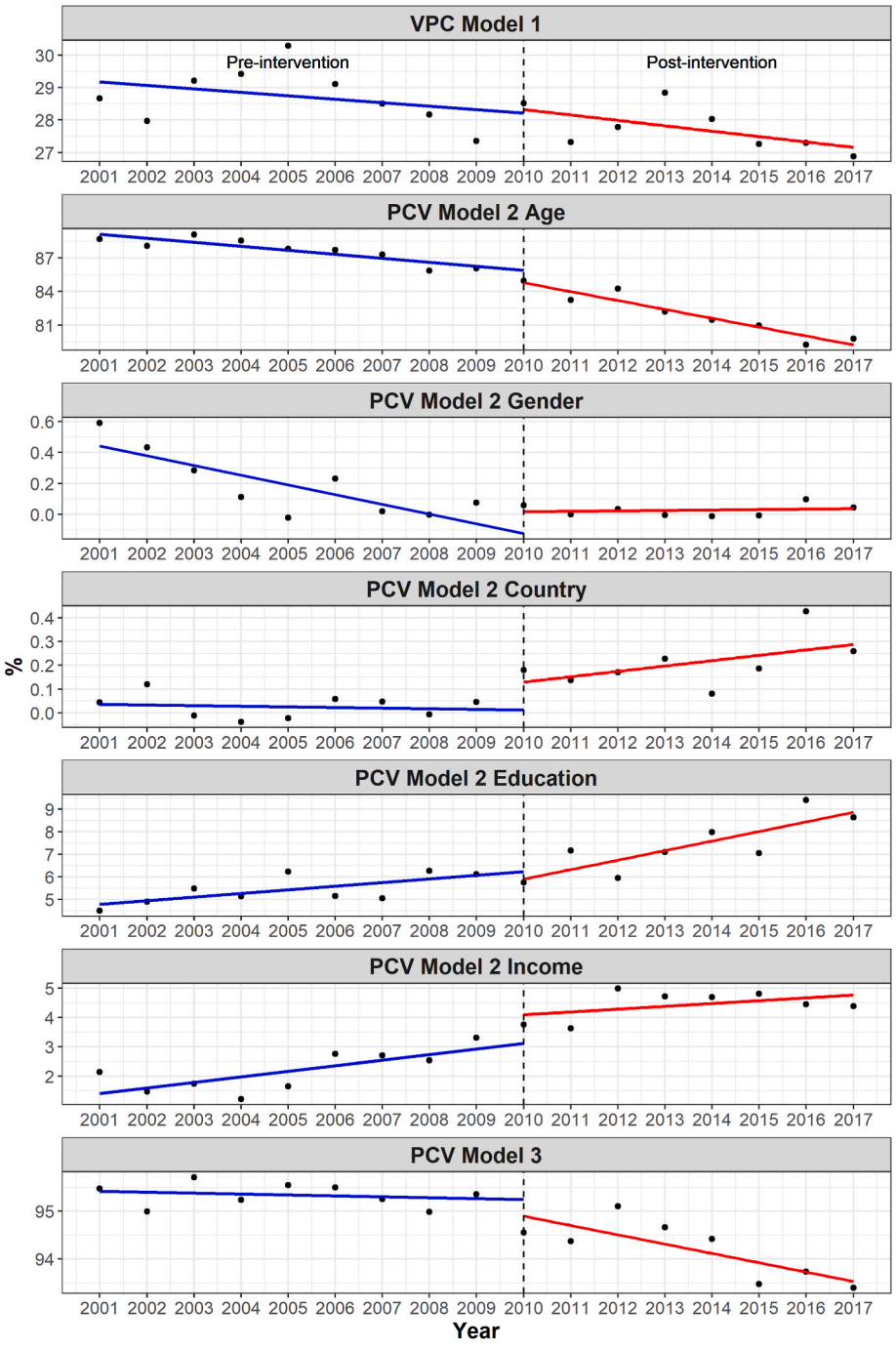

Fig. 3. Illustration of interrupted time series analyses of intersectional inequities in avoidable hospitalizations before (2001–2009) and after (2010–2017) a 2010 primary health care reform in Sweden. Outcomes are random effect estimates (%) from multilevel models: variance partition coefficient (VPC) from empty intersectional model (Model 1), proportional change in variation (PCV) from partially adjusted intersectional models (Models 2) and PCV from fully adjusted intersectional interaction model (Model 3).

ITSA to capture key intersectional effects from the corresponding MAIHDA, but this also means that only a limited numbers of parameters were considered. Although fixed effect estimates would also be analytically possible to incorporate into an ITSA, the large number of 162 strata considered would make such an analysis unwieldy and its interpretation cumbersome. For the same reason we limited the mapping to collapsed pre- and post-reform periods, rather than for each individual year.

A final critical reflection on the applicability of the proposed method intended as a bridge between the conceptually and analytically appealing features of MAIHDA and the rigorous evidence provided by the ITS design is worth mentioning. MAIHDA is a comprehensive method, but more suitable for very large data, which in many settings may not be available. Moreover, even a cross-sectional MAIHDA requires a series of models that produce a battery of estimates, which, while capturing a high degree of the complexity that intersectional approaches indeed promote, also leaves a considerable amount of interpretation left to the researcher. The analytical and interpretational challenges are multiplied with the extension to an ITS design. The focus on random effects, in this study VPC and PCV, can be motivated by the general desire moving from mean-centric methods to approaches taking variation into account, by their specifically relevant interpretation

within an intersectional framework, as well as the pragmatic need for summary estimates of outcomes for evaluative analysis, using this or other methods. However, familiarity with their interpretation is not as widespread as conventional mean-centric measures, which may limit their practical applicability, particularly in a policy actor setting. Lastly, the analytical approach used is quite intensive, both when it comes to computational power needed (owing to the large data set) and the human work needed to perform all analyses (e.g., the series of analyses needed to generate outcome observations for the ITSA). In that regard, alternative evaluative intersectional methods developed from individual-level AIHDA (e.g. (Gustafsson et al., 2022),) or other methods considering less intersectional strata (e.g., (Jackson et al., 2016)) may be suitable starting points.

Taken together, the proposed analytical approach represents a unique addition to the growing toolbox of intersectional epidemiological analysis (Bauer et al., 2021, 2022; Harari and Lee, 2021; Mahendran et al., 2022a, 2022b), specifically when it comes to analyzing how large-scale interventions, policies and reforms impact on population-level intersectional health inequities. Considering the long-standing emphasis of studying the impact of policies within intersectionality-informed health research (Bauer, 2014; Hankivsky, 2012), this is an important contribution to the field. We welcome proposals for additional and alternative methodological approaches to study the impact of reforms on intersectional health inequities, as well as a greater substantive focus on health system and health care in intersectional epidemiology.

4.2. Conclusions and implications for policy and future research

The present report illustrates the complexity of potential inequitable consequences of a Swedish reform promoting privatization of Swedish PHC. The findings suggest that the reform contributed to an overall reduction in avoidable hospitalizations, as well as a reduction in age disparities. However, the reform also seems to have increased socioeconomic inequities in avoidable hospitalizations and increasing importance of interactions between complex social positions. Certain social groups, including socioeconomically disadvantaged groups born in the Nordic countries, seem to have benefited the least from the population-average gain of the reform. The study warrants a greater attention to the potentially complex effects that health reforms can have on inequities in health and health care outcomes, which may not be immediate apparent in conventional. To enable this, further methodological development would be needed.

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CRediT authorship contribution statement

Per E. Gustafsson: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft. **Osvaldo Fonseca-Rodríguez:** Data curation, Formal analysis, Software, Validation, Visualization, Writing – review & editing. **Sara Castel Feced:** Formal analysis, Software, Validation, Writing – review & editing. **Miguel San Sebastián:** Conceptualization, Methodology, Writing – review & editing. **João Luiz Bastos:** Conceptualization, Writing – review & editing. **Paola A. Mosquera:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Writing – review & editing.

Declarations of competing interest

None.

Data availability

The data that has been used is confidential.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2024.116589.

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