Inequalities in COVID-19 deaths by migration background during the first wave, interwave period and second wave of the COVID-19 pandemic: a closed cohort study of 17 million inhabitants of the Netherlands

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► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/jech-2022-219521).

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Received 5 July 2022
Accepted 5 October 2022
Published Online First 31 October 2022

To cite: Chilunga FP, Stoeldraijer L, Agyemang C, *et al*. *J Epidemiol Community Health* 2023;**77**:9–16.

ABSTRACT

Background It is not known how differences in COVID-19 deaths by migration background in the Netherlands evolved throughout the pandemic, especially after introduction of COVID-19 prevention measures targeted at populations with a migration background (in the second wave). We investigated associations between migration background and COVID-19 deaths across first wave of the pandemic, interwave period and second wave in the Netherlands.

Methods We obtained multiple registry data from Statistics Netherlands spanning from 1 March 2020 to 14 March 2021 comprising 17.4 million inhabitants. We estimated incidence rate ratios for COVID-19 deaths by migration background using Poisson regression models and adjusted for relevant sociodemographic factors.

Results Populations with a migration background, especially those with Turkish, Moroccan and Surinamese background, exhibited higher risk of COVID-19 deaths than the Dutch origin population throughout the study periods. The elevated risk of COVID-19 deaths among populations with a migration background (as compared with Dutch origin population) was around 30% higher in the second wave than in the first wave.

Conclusions Differences in COVID-19 deaths by migration background persisted in the second wave despite introduction of COVID-19 prevention measures targeted at populations with a migration background in the second wave. Research on explanatory mechanisms and novel prevention measures are needed to address the ongoing differences in COVID-19 deaths by migration background.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The progress of inequalities in COVID-19 deaths by migration background across COVID-19 waves has been reported in high-income countries such as the UK.

WHAT THIS STUDY ADDS

⇒ In contrast to other high-income countries (eg, UK), the Netherlands introduced COVID-19 prevention measures targeted at populations with a migration background on top of the general COVID-19 prevention measures.

⇒ We show that inequalities in COVID-19 deaths by migration background persisted across the waves despite introduction of COVID-19 prevention measures targeted at populations from a migration background.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ With vaccine uptake low in populations with a migration background, and COVID-19 prevention measures relaxed in most countries, we call for better COVID-19 prevention measures targeting populations with migration background.

INTRODUCTION

In the early periods of the COVID-19 pandemic, differences in SARS-CoV-2 infection by migration background and subsequent COVID-19 deaths were reported across the world.[1 2] Specifically, populations with a migration background in high-income countries (HICs) were reported to have disproportionately higher SARS-CoV-2 infection and COVID-19 deaths rates than populations without a migration background.[3] This increased infection and mortality among populations with a migration background was attributed to several factors including working in the front line, living in large households, having a higher burden of underlying medical conditions and barriers to accessing COVID-19 information.[4]

Indications of disproportionate COVID-19 deaths among populations with a migration background were also apparent during the first wave in the Netherlands (March to June 2020).[5] As a result, at the beginning of the second wave (September 2020), several interventions were introduced to mitigate the higher rates of SARS-CoV-2 infections and prevent excess COVID-19 mortality among populations with a migration background. Some of these interventions included translating COVID-19 messages into several languages,[6] conducting awareness campaigns in locations with a large proportion of people with a migration background[7] and making COVID-19 testing free for all.[8] While

it has been reported that inequalities in SARS-CoV-2 infection by migration background increased during the second wave in the Netherlands (despite introduction of COVID-19 prevention measures targeted at populations with a migration background),[9] little is known of how COVID-19 deaths rates evolved longitudinally in this context. As a matter of fact, COVID-19 death rates can be influenced by factors like having less access to healthcare, type of treatment received, etc, which do not necessarily influence SARS-CoV-2 infection.[10]

Previous studies in the UK showed that COVID-19 deaths decreased in participants of African descent as compared with participants of European descent from the first to second wave.[10 11] However, South Asian origin populations continued to have higher rates of COVID-19 deaths compared with the British people of European descent.[10 11] Due to contextual differences with the Netherlands (different population groups, languages, health systems, living environment, cultural dynamics etc), we hypothesised that COVID-19 deaths would evolve differently (across the various waves) in the Netherlands than in the UK. Therefore, it is imperative to also know how COVID-19 deaths rates evolved after introduction of COVID-19 measures that targeted populations with a migration background in the Netherlands.

We; therefore, investigated trends in COVID-19 deaths by migration background during first wave, interwave period and second wave (period when COVID-19 prevention measures targeted at populations with a migration background were introduced) in the Netherlands. Since COVID-19 deaths can be confounded by disproportionate rates in vaccination, we used data up to 14 of March 2021, just before COVID-19 vaccination was available to all members of the whole society. Our findings would help call for better measures/interventions if disproportionally higher COVID-19 deaths persisted among populations with migration background.

METHODS

Study population and design

This study was based on a closed cohort design. Using the basic population register from Statistics Netherlands (CBS, https://www.cbs.nl/en-gb), all persons registered as Dutch residents on 1 March 2020 (approximately 17.4 million inhabitants) were followed for mortality between 1 March 2020 and 14 March 2021.

COVID-19 waves

COVID-19 waves were derived from the number of COVID-19 deaths per day as reported by Statistic Netherlands. An interactive graphic dashboard is available at https://coronadashboard.government.nl/landelijk/sterfte.[12] The period with less than five COVID-19 deaths per day (ie, interwave period) was used to separate first wave from second wave. The first wave therefore occurred from 1 March 2020 to 7 June 2020, the interwave period from 8 June 2020 to 20 September 2020, and second wave from 21 September 2020 to 14 March 2021. The second wave was further categorised into two parts based on a dip in COVID-19 deaths in this period (https://coronadashboard.government.nl/landelijk/sterfte). As such, 21 September 2020 to 6 December 2020 was considered first part of second wave, while 7 December 2020 to 14 March 2020 was considered second part of second wave.

Measurements

Data on migration background were obtained from the continuous population registry. Migration background was defined according to the standard classification of Statistics Netherlands.[13] This classification considers the country of birth of residents and their parents, thus includes immigrants and their descendants. Participants are considered of Dutch origin if: (1) they were born in the Netherlands, and at least one parent born was also born in the Netherlands or (2) they were born abroad but both their parents were born in the Netherlands. On the other hand, participants are considered to have a migration background if: (1) they were born abroad and had at least one parent born abroad (immigrants) or (2) they were born in the Netherlands, but both their parents were born abroad (immigrants' descendants). At first, countries of origin were broadly classified based on World Bank's low-income and middle-income country (LMIC) and HIC categories. Second, countries of origin were classified into more specific subgroups, that is, five countries of origin with the largest number of inhabitants (Turkey, Morocco, Suriname, Dutch Antilles and Indonesia), and the rest into 'other LMIC origin' and 'other HIC origin'. Of note, Indonesia is officially categorised as an HIC in the Netherlands due to its socioeconomic position and sociocultural relations with the Netherlands.[13] We; therefore, used this official HIC categorisation in our study.

Data on COVID-19 deaths were obtained from the cause of death registry. ICD codes (U07.1, U07.2) were used to determine COVID-19 as the underlying cause of death. This included cases where, according to the reporting physician, COVID-19 was suspected but could not be verified by tests. Such tests were often not made due to absence of test materials and shortage of time during the healthcare emergencies at the beginning of the COVID-19 pandemic in spring 2020.

Age, sex, household size, region of residence and residential care status were obtained from the continuous population registry. They were categorised as follows: age into 0–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, 85–89, 90–94, 95+ years, sex into male and female, and household size was into one-person, two-person, three-person, four-person and five-person plus households. Region of residence within the Netherlands was categorised into two groups: a collective of four largest cities (Amsterdam, Rotterdam, The Hague and Utrecht) vs the rest of the Netherlands. Residential care status (ie, residence in institutions that provide day-to-day care for the elderly and people with disabilities for example, nursing homes) was categorised based on residence in long term care facilities, receiving non-residential care and not receiving any care.

Total net household wealth was obtained from tax registries linked to the population registry. It was measured as the sum of all sources of income with deductions from tax and social premiums, as well as financial assets owned by household members, including the value of house less mortgages (as of January 2018). It was corrected for the size and composition of the household using the standard equivalence formula used by Statistics Netherlands. Participants without data on household wealth were classified as 'unknown'. Household wealth was grouped into five quintiles based on its distribution in the total Dutch population (ages 18 years and older).

Statistical analysis

All analyses were conducted in R statistical software (V.4.0.2). Analyses were first performed for the broad country of origin groups (Dutch origin, LMIC origin, HIC origin), and later for the specific country of origin groups (Dutch origin, Turkish origin, Moroccan origin, Surinamese origin, Indonesian Origin, Dutch Antilles origin, Other LMIC origin, Other HIC origin).

Baseline characteristics were presented as proportions per broad and specific country of origin. Age-standardised mortality rates (ASMR; per 100 000 persons) were calculated via epitools package across COVID-19 waves using direct standardisation. Poisson regression models (via mfx package) were used to measure associations between migration background (predictor variable) and COVID-19 deaths (outcome variable). The offset variable was the number of residents at baseline. The Poisson regression models were initially performed for the total study period and thereafter by COVID-19 waves. Age and sex were adjusted as potential confounders, while residential care status, region of residence, household size and household wealth were included in Poisson models to ascertain whether they would explain the relationship between migration background, and COVID-19 mortality (ie, explanatory factors). Incidence rate ratios (IRRs) were then reported together with their 95% CIs. All analyses were two tailed at an alpha of 0.05.

RESULTS

Baseline characteristics

A total of 17.4 million people who were registered as Dutch residents by 1 March 2020 were included in the study (table 1, online supplemental appendix 1). The majority (75.7%) were of Dutch origin. Population with a migration background were represented as follows: Turkish origin (2.4%), Moroccan origin

Table 1 Baseline characteristics of participants according to broader country of origin categories of Dutch, LMIC or HIC in the Netherlands

Variable	Name	Total*	%	Dutch*	%	LMIC origin*	%	HIC origin*	%
Migration background									
	Dutch origin	13 183	75.7						
	LMIC origin	2403	13.8						
	HIC origin	1835	10.5						
Sex									
	Female	8766	50.3	6618	50.2	1198	49.9	950	51.8
	Male	8655	49.7	6565	49.8	1205	50.1	885	48.2
Age categories (years)									
	< 50	10 142	58.2	7145	54.2	1865	77.6	1132	61.7
	50–54	1287	7.4	1001	7.6	154	6.4	132	7.2
	55–59	1267	7.3	1017	7.7	130	5.4	120	6.6
	60–64	1144	6.6	945	7.2	95	3.9	104	5.7
	65–69	1014	5.8	854	6.5	64	2.6	96	5.3
	70–74	986	5.7	847	6.4	43	1.8	96	5.2
	75–79	662	3.8	572	4.3	28	1.1	62	3.4
	80–84	473	2.7	405	3.1	17	0.7	51	2.8
	85–89	284	1.6	251	1.9	6	0.3	27	1.5
	90–94	126	0.7	113	0.9	2	0.1	11	0.6
	95+	36	0.2	33	0.2	0	0	3	0.2
Region of residence									
	Main municipal health regions	4869	28.0	3004	22.8	1210	50.4	655	35.7
	Rest of Netherlands	12 549	72.0	10 177	77.2	1193	49.6	1180	64.3
Residential care status									
	Residential care	270	1.5	231	1.8	14	0.6	25	1.3
	Non-residential care	187	1.1	148	1.1	23	0.9	17	0.9
	Not in care	16 964	97.4	12 803	97.1	2367	98.5	1794	97.8
Household size (in persons)									
	1 person	3396	19.5	2481	18.8	439	18.3	477	26
	2 people	5309	30.5	4279	32.5	451	18.8	579	31.5
	3 people	2767	15.9	2031	15.4	431	17.9	305	16.6
	4 people	3781	21.7	2920	22.2	529	22	332	18.1
	5 people +	2167	12.4	1471	11.2	554	23	142	7.7
Household wealth (quantiles)									
	1 (highest)	3103	17.8	2714	20.6	125	5.2	264	14.4
	2	3318	19.0	2829	21.5	216	9	273	14.9
	3	3370	19.3	2777	21.1	303	12.6	290	15.8
	4	3218	18.5	2422	18.4	467	19.4	328	17.9
	5 (lowest)	3393	19.5	2009	15.2	994	41.4	390	21.3
	Unknown	1020	5.9	432	3.3	298	12.4	290	15.8

First, countries of origin were broadly classified based on World Bank's 'LMIC' and 'HIC' categories. Second, the countries were classified into more specific subgroups, that is, five countries of origin with the largest number of inhabitants (Turkey, Morocco, Suriname, Dutch Antilles and Indonesia), and the remain groups into other LMIC origin and other HIC origin.
*Population per first March 2020 times 1000.
HIC, high-income countries; LMIC, low-income and middle-income country.

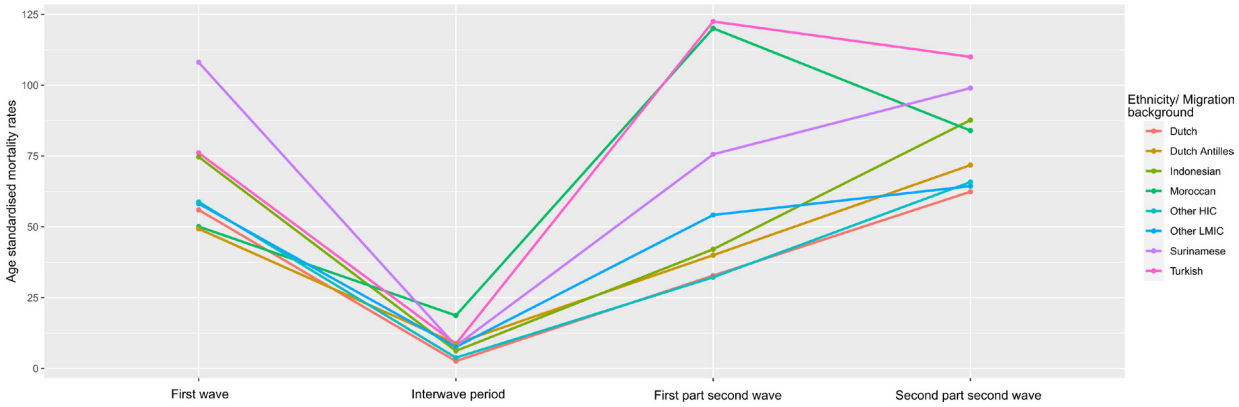

Figure 1 Age-standardised mortality rates for COVID-19 by migration background (per 100 000 persons) across waves. HIC, high-income country; LMIC, low-income and middle-income country.

(2.4%), Surinamese origin (2%), Dutch Antilles origin (0.9%), Indonesian origin (2%), other LMIC origin (6.1%) and other HIC origin (8.5%). There were slightly more females (50.3%) than males (49.7%). Dutch, Indonesian and other HIC origin populations had a larger proportion of older individuals (>70 years) than the other population groups. The majority of Moroccan, Surinamese and Dutch Antillean origin populations resided in the four main cities (ie, municipal health service regions within the main cities) compared with the other population groups. Dutch and Indonesian origin populations received more residential care than the other population groups. Populations of Turkish and Moroccan origin had the largest household sizes compared with the other population groups. Dutch and Indonesian origin populations had a larger proportion of higher household wealth than the other population groups.

Age-standardised COVID-19 mortality rates (per 100 000 persons)

During the first wave, age-standardised COVID-19 mortality rates (ASMR; per 100 000 persons) were highest in the Surinamese origin population (108.1, 95% CI 91.4 to 127.4) and lowest in the Dutch Antilles origin population (49.3, 95% CI 29.0 to 86.0; figure 1, online supplemental appendix 2). In the interwave period, ASMRs were highest in the Moroccan origin population (18.7, 95% CI 10.8 to 38.9) and lowest in the Dutch origin population (2.6, 95% CI 2.4 to 2.9). In the first part of the second wave (after introduction of COVID-19 prevention measures targeted at populations with a migration background), ASMRs were highest in the Turkish origin population (122.5, 95% CI 99.5 to 155.7) and lowest in the Dutch origin population (32.8, 95% CI 31.9 to 33.7) and in the Other HIC origin population (32.2, 95% CI 29.1 to 35.6). During the second part of second wave (after introduction of COVID-19 prevention measures targeted at populations with a migration background), ASMRs were again highest in the Turkish population (110, 95% CI 88.3 to 142.2) and lowest in the Dutch origin population (62.4, 95% CI 61.2 to 63.7).

Association between migration background and COVID-19 deaths in total study period

Compared with the Dutch origin population, populations with a migration background had a higher risk of COVID-19 deaths after age and sex adjustments in the total study period (table 2). The risk of COVID-19 deaths was highest in populations with an LMIC origin. In fact, populations with a Turkish, Moroccan and Surinamese background had almost twice the risk of COVID-19 deaths as compared with the Dutch origin population (IRRs=2.30, 1.95 and 2.08, respectively). Adjusting for relevant sociodemographic factors (ie, region of residence, residential care status, household size and household wealth) had a modest impact on the findings. For instance, after adjusting for multiple sociodemographic factors, the age-adjusted and sex-adjusted IRRs for Turkish, Moroccan and Surinamese origin populations (presented above) decreased to 1.81, 1.84 and 1.63, respectively.

Association between migration background and COVID-19 deaths across waves

Across all COVID-19 waves, the risk of COVID-19 deaths was highest in LMIC origin populations, intermediate in HIC origin populations and lowest in Dutch origin population after adjusting for age and sex (table 3). On the other hand, the actual magnitude of the risk of COVID-19 deaths varied from period to period. For instance, during the first wave, Surinamese origin populations had the highest risk of COVID-19 deaths, almost twice that of the Dutch origin population (IRR=1.99). In the interwave period, risk of COVID-19 deaths was most elevated in Moroccan origin population to about eight times higher than the Dutch origin population (IRR=7.74). In the second wave (after introduction of COVID-19 prevention measures targeted at populations with a migration background), the highest observed risk of COVID-19 deaths was in the Turkish origin population. It was about four times higher than the Dutch origin population in the first part of the second wave (IRR=4.02) and two times higher in the second part of the second wave (IRR=2.03). Adjustments for explanatory sociodemographic factors (ie, region of residence, residential care status, household size and household wealth) across COVID-19 waves had modest impact on the findings. For example, after adjusting for the multiple socio-demographic factors, the age-adjusted and sex-adjusted IRR observed among Surinamese origin populations in the first wave decreased to 1.64, while that observed among Moroccan origin populations in the interwave period decreased to 6.57. Similarly, the age-adjusted and sex-adjusted IRR reported among Turkish origin populations decreased to 2.79 in the first part of the second wave, and to 1.60 in the second part of the second wave.

DISCUSSION

Summary of findings

In our study of COVID-19 deaths by migration background across the first wave, interwave period and second wave (after

Table 2 Associations between migration background and COVID-19 deaths between 1 March 2020 and 14 March 2021 (total study period) in the Netherlands

Variable	Name	No of deaths (27 949)	Model 1 IRR (95% CI)	Model 2 IRR (95% CI)	Model 3 IRR (95% CI)
Migration background (broad categories)					
	Dutch origin	23 365	1.00 (ref)	1.00 (ref)	1.00 (ref)
	LMIC origin	1679	1.84 (1.75 to 1.94)	1.69 (1.61 to 1.78)	1.54 (1.46 to 1.62)
	HIC origin	2905	1.14 (1.10 to 1.19)	1.13 (1.08 to 1.17)	1.11 (1.07 to 1.16)
Migration background (specific categories)					
	Dutch origin	23 365	1.00 (ref)	1.00 (ref)	1.00 (ref)
	Turkish origin	378	2.30 (2.07 to 2.54)	2.03 (1.83 to 2.25)	1.81 (1.64 to 2.01)
	Moroccan origin	372	1.95 (1.76 to 2.16)	2.09 (1.89 to 2.32)	1.84 (1.65 to 2.04)
	Surinamese origin	496	2.08 (1.90 to 2.27)	1.74 (1.59 to 1.91)	1.63 (1.49 to 1.78)
	Dutch Antilles origin	86	1.39 (1.13 to 1.72)	1.05 (0.85 to 1.29)	0.98 (0.79 to 1.21)
	Other LMIC origin	347	1.35 (1.22 to 1.50)	1.34 (1.20 to 1.49)	1.22 (1.10 to 1.36)
	Indonesian (HIC) origin	933	1.39 (1.30 to 1.48)	1.34 (1.20 to 1.49)	1.34 (1.25 to 1.43)
	Other HIC origin	1972	1.06 (1.01 to 1.11)	1.05 (1.00 to 1.10)	1.03 (0.99 to 1.08)

First, countries of origin were broadly classified based on World Bank's 'LMIC' and 'HIC' categories. Second, the countries were classified into more specific subgroups, that is, five countries of origin with the largest number of inhabitants (Turkey, Morocco, Suriname, Dutch Antilles and Indonesia), and the remain groups into other LMIC origin and other HIC origin. Indonesia is officially categorised as a high-income country in the Netherlands due to the history between the two countries. Model 1=adjusted for age and sex, model 2=adjusted for age, sex, region of residence, residential care status, household size, model 3=adjusted for age, sex, region of residence, residential care status, household size and household wealth.
HIC, high-income countries; IRR, Incidence rate ratio; LMIC, low-income and middle-income country.

introduction of COVID-19 prevention measures targeted at populations with a migration background) in the Netherlands, we have found that populations with a migration background, especially those with Turkish, Moroccan and Surinamese background, exhibited higher risk of COVID-19 deaths than the Dutch origin population throughout all the study periods. The elevated risk of COVID-19 deaths among populations with a migration background (as compared with Dutch origin population) was around 30% higher in the second wave (after introduction of COVID-19 prevention measures targeted at populations with a migration background) than in the first wave.

Interpretation of findings

The increase in COVID-19 mortality rates among populations with a migration background (as compared with Dutch origin populations) in the second wave (after introduction of COVID-19 prevention measures targeting these populations) than the first wave was unexpected.[7 8 14] A previous study in the UK had reported a decrease in COVID-19 mortality among populations of African descent as compared with British people of European descent during these periods.[10 11] As such, we had expected that differences in COVID-19 deaths by migration background in the second wave (after introduction of COVID-19 prevention measures targeted at populations with a migration background) would decrease below those reported in the first wave.

At first glance, the elevated risk of COVID-19 deaths among populations with a migration background (as compared with Dutch origin population) observed in the second wave than the first wave could be related to SARS-CoV-2 infection rates. Like in our study, a large study in the Netherlands involving multiple population groups showed that SARS-CoV-2 incidence increased in populations with a migration background (as compared with the Dutch origin population) in the second wave than the first wave.[9] These findings suggest that trends in COVID-19 mortality observed in our study could have largely been influenced by SARS-CoV-2 infections. Moreover, sociodemographic, behavioural and medical factors like large household sizes, less household income, working in front-line occupations and residence in overcrowded urban centres, tobacco smoking, underlying medical conditions, limited access to healthcare, etc, could have been mediators of the relationship between country of origin, SARS-CoV-2 infections and COVID-19 mortality.[4] All these explanatory factors have been previously reported as more prominent in populations with a migration background than the Dutch origin population.[15–19] To our surprise, adjustment of household size, household wealth and residence in overcrowded urban centres in our analyses had a modest impact on the findings. This suggests that other unmeasured factors (ie, behavioural factors, underling medical conditions, hospital factors and health seeking behaviours, working in the front line) have much greater influence on the relationship between migration background and COVID-19 mortality than the measured sociodemographic factors. Since our study was based on national registry data, further studies are needed to understand how behavioural factors, underling medical conditions, hospital factors and health seeking behaviours influence COVID-19 deaths over time by migration background.

Although the total number of COVID-19 deaths were lowest in the interwave period, the relative magnitude of risk of COVID-19 deaths (ie, IRRs derived from Poisson regression models) among populations with a migration background were highest in this period. It is possible that the magnitude of risk was inflated during this period due to the small number of absolute deaths (538 COVID-19 deaths in total during this period). The larger differences in the risk of COVID-19 deaths by migration background seen in this period could also have just been a prologue to the differences observed in the second wave. In addition, there were less COVID-19 prevention measures implemented/advised during the interwave period as compared with the first wave (eg, strict lockdown in the first wave).[20] Such lifting of COVID-19 prevention measures in the interwave period could have possibly also contributed to the larger differences in COVID-19 deaths by migration background observed in this period.

Our results have several implications. For instance, with less vaccine uptake reported in populations with a migration background, and with COVID-19 prevention measures relaxed in most countries, the risk of deaths from COVID-19 are likely to

Table 3 Associations between migration background and COVID-19 deaths across the various waves in the Netherlands

Variable	No of deaths	Model 1 IRR (95% CI)	Model 2 IRR (95% CI)	Model 3 IRR (95% CI)
First wave (1 March 2020–7 June 2020)				
Migration background (broad categories)				
Dutch origin	8501	1.00 (ref)	1.00 (ref)	1.00 (ref)
LMIC origin	469	1.41 (1.29 to 1.55)	1.35 (1.22 to 1.48)	1.21 (1.05 to 1.40)
HIC origin	1049	1.14 (1.07 to 1.21)	1.12 (1.05 to 1.19)	1.03 (0.67 to 1.58)
Migration background (specific categories)				
Dutch origin	8501	1.00 (ref)	1.00 (ref)	1.00 (ref)
Turkish origin	93	1.55 (1.26 to 1.90)	1.43 (1.16 to 1.76)	1.34 (1.09 to 1.64)
Moroccan origin	71	1.02 (0.81 to 1.29)	1.17 (0.92 to 1.48)	1.08 (0.85 to 1.36)
Surinamese origin	172	1.99 (1.71 to 2.31)	1.72 (1.47 to 2.00)	1.64 (1.41 to 1.91)
Dutch Antilles origin	24	1.07 (0.72 to 1.60)	0.81 (0.54 to 1.21)	0.76 (0.51 to 1.14)
Other LMIC origin	109	1.17 (0.96 to 1.41)	1.18 (1.47 to 1.32)	1.11 (0.92 to 1.35)
Indonesian (HIC) origin	331	1.35 (1.21 to 1.51)	1.32 (1.18 to 1.47)	1.32 (1.18 to 1.47)
Other HIC origin	718	1.06 (0.98 to 1.14)	1.05 (0.97 to 1.13)	1.04 (0.96 to 1.12)
Interwave (7 June 2020–20 September 2020)				
Migration background (broad categories)				
Dutch origin	399	1.00 (ref)	1.00 (ref)	1.00 (ref)
LMIC origin	65	4.29 (3.28 to 5.61)	3.40 (2.57 to 4.49)	3.01 (2.25 to 4.01)
HIC origin	74	1.73 (1.35 to 2.22)	1.68 (1.31 to 2.16)	1.66 (1.30 to 2.13)
Migration background (specific categories)				
Dutch origin	399	1.00 (ref)	1.00 (ref)	1.00 (ref)
Turkish origin	8	3.01 (1.49 to 6.08)	2.59 (1.28 to 5.26)	2.24 (1.10 to 4.58)
Moroccan origin	24	7.74 (5.10 to 11.73)	7.75 (5.02 to 11.96)	6.57 (4.21 to 10.24)
Surinamese origin	15	3.76 (2.24 to 6.31)	2.43 (1.44 to 4.11)	2.23 (1.32 to 3.79)
Dutch Antilles origin	4	3.94 (1.47 to 10.59)	2.44 (0.91 to 6.56)	2.23 (0.83 to 6.02)
Other LMIC origin	14	3.16 (1.84 to 5.42)	2.84 (1.65 to 4.88)	2.53 (1.46 to 4.38)
Indonesian (HIC) origin	27	2.33 (1.58 to 3.44)	2.10 (1.42 to 3.10)	2.11 (1.43 to 3.12)
Other HIC origin	47	1.51 (1.11 to 2.04)	1.51 (1.12 to 2.05)	1.49 (1.10 to 2.01)
First part second wave (21 September 2020–6 December 2020). COVID-19 prevention measures targeted for populations with a migration background introduced here.				
Migration background (broad categories)				
Dutch origin	4984	1.00 (ref)	1.00 (ref)	1.00 (ref)
LMIC origin	565	2.92 (2.68 to 3.19)	2.32 (2.12 to 2.54)	2.08 (1.89 to 2.29)
HIC origin	586	1.08 (0.99 to 1.18)	1.05 (0.97 to 1.15)	1.04 (0.96 to 1.14)
Migration background (specific categories)				
Dutch	4984	1.00 (ref)	1.00 (ref)	1.00 (ref)
Turkish origin	141	4.02 (3.40 to 4.76)	3.17 (2.67 to 3.76)	2.79 (2.35 to 3.31)
Moroccan origin	161	3.91 (3.34 to 4.58)	3.52 (3.00 to 4.14)	3.03 (2.57 to 3.57)
Surinamese origin	141	2.80 (2.36 to 3.31)	1.96 (1.65 to 2.33)	1.82 (1.53 to 2.16)
Dutch Antilles origin	21	1.62 (1.05 to 2.48)	1.11 (0.72 to 1.70)	1.03 (0.67 to 1.58)
Other LMIC origin	101	1.87 (1.54 to 2.29)	1.65 (1.35 to 2.01)	1.49 (1.22 to 1.82)
Indonesian (HIC) origin	188	1.31 (1.13 to 1.52)	1.21 (1.05 to 1.40)	1.21 (1.05 to 1.40)
Other HIC origin	398	1.00 (0.90 to 1.11)	0.99 (0.90 to 1.10)	0.98 (0.88 to 1.08)
Second part second wave (07 December 2021 – 14 March 2021).				
Migration background (broad categories)				
Dutch origin	9481	1.00 (ref)	1.00 (ref)	1.00 (ref)
LMIC origin	580	1.56 (1.43 to 1.70)	1.52 (1.39 to 1.66)	1.36 (1.25 to 1.49)
HIC origin	1196	1.16 (1.09 to 1.23)	1.15 (1.08 to 1.22)	1.13 (1.07 to 1.20)
Migration background (specific categories)				
Dutch origin	9481	1.00 (ref)	1.00 (ref)	1.00 (ref)
Turkish origin	136	2.03 (1.71 to 2.41)	1.85 (1.56 to 2.19)	1.60 (1.35 to 1.90)
Moroccan origin	116	1.50 (1.25 to 1.80)	1.70 (1.42 to 2.05)	1.45 (1.20 to 1.75)
Surinamese origin	168	1.72 (1.47 to 2.00)	1.59 (1.36 to 1.85)	1.47 (1.26 to 1.71)
Dutch Antilles origin	37	1.46 (1.06 to 2.01)	1.16 (0.84 to 1.61)	1.09 (0.79 to 1.50)
Other LMIC origin	123	1.17 (0.98 to 1.40)	1.22 (1.02 to 1.46)	1.09 (0.91 to 1.31)
Indonesian (HIC) origin	387	1.41 (1.28 to 1.56)	1.40 (1.26 to 1.55)	1.40 (1.26 to 1.55)
Other HIC origin	809	1.07 (0.99 to 1.15)	1.06 (0.98 to 1.14)	1.04 (0.97 to 1.12)

Continued

Table 3 Continued

Variable	No of deaths	Model 1 IRR (95% CI)	Model 2 IRR (95% CI)	Model 3 IRR (95% CI)

Indonesia is officially categorised as an HIC in the Netherlands due to the history between the two countries. First, countries of origin were broadly classified based on World Bank's 'LMIC' and 'HIC' categories. Second, the countries were classified into more specific subgroups, that is, five countries of origin with the largest number of inhabitants (Turkey, Morocco, Suriname, Dutch Antilles and Indonesia), and the remain groups into other LMIC origin and other HIC origin model 1=adjusted for age and sex, model 2=adjusted for age, sex, region of residence, residential care status, household size, model 3=adjusted for age, sex, region of residence, residential care status, household size and household wealth.
HIC, high-income country; IRR, Incidence rate ratio; LMIC, low-income and middle-income country.

be exacerbated.[21] Evidently, relaxation of COVID-19 prevention measures should be conducted considering the higher risk of mortality in populations with a migration background. Moreover, novel measures are still needed to address discrepancies in COVID-19 mortality.

Strengths and limitations

The biggest strength of our study is that it covered the entire Dutch population. As a result, it has sufficient statistical power for detailed mapping of COVID-19 deaths in relationship to migration background. Moreover, thanks to linkage to tax registers, household wealth could be accurately measured and adjusted for. Second, our study is longitudinal in nature, which enabled clear tracking of COVID-19 deaths across time. In addition, this enabled us to be the first to report what happens to COVID-19 deaths during the interwave period. Our study is not without limitations. First, ascertainment of COVID-19 deaths based on death certificates. The coding of these certificates at statistical Netherlands is based on physicians' reports of COVID-19 as the underlying cause of death. The possibility of misclassifications cannot be ruled out. Second, other important covariates such as history of underlying medical conditions, behavioural factors and working in the front-line occupations which could have further helped explain our findings were not available and hence not adjusted for in our study.

CONCLUSIONS

Our paper shows that despite the introduction of COVID-19 prevention measures targeted at populations with a migration background at the beginning of the second wave in the Netherlands, populations with a migration background continued to experience disproportionately high rates of COVID-19 deaths as compared with the Dutch origin population. These differences may have persisted or even widened in later waves. For instance, less vaccine uptake has been reported in populations with a migration background, and COVID-19 prevention measures have been relaxed in most countries, which would further exacerbate the risk of deaths from COVID-19 directly after the time period we studied.[21] Evidently, novel measures are needed to address these ongoing discrepancies, taking into account future research on how the COVID-19 deaths progressed across different population groups after the introduction of COVID-19 vaccines. Special attention should be placed on LMIC origin populations, such as Turkish, Moroccan and Surinamese origin populations, who exhibit the most elevated risk of COVID-19 deaths.

Acknowledgements The authors are very grateful to Statistics Netherlands for providing access to the data that was used in this study.

Contributors FPC, LS, CH and AEK conceived and designed the study. FPC and LS analysed the data. FPC wrote the paper with LS, CH and AEK. All authors FPC, LS, CA, KS, CH and AEK participated in drafting the article or revising it critically for content. AEK is the guarantor of this work and accepts full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by Statistics Netherlands (CBS). CBS can grant access to microdata for scientific research purposes. Access is structured in such a way that authorised external researchers can only consult the microdata within CBS' secure online environment, using a remote access facility, maintaining maximum control over the intended uses, privacy and information security. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request.

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