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Title:

The effect of household crowding and composition on health in an Inuit cohort in Greenland

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## Abstract

**Aims:** To investigate the association between household crowding and household composition and self-rated health and mental health (GHQ-scale) among the Inuit in Greenland. As poor housing conditions are a concern in Greenland, especially in the villages, where socioeconomic standards in general are lower.

**Methods:** A cohort of 1282 adults participated in two population-based surveys in Greenland, the Inuit Health in Transition survey 2005-2010 (baseline) and the Health survey in Greenland 2014 (follow-up). Associations between household conditions at baseline and health outcomes at follow-up (poor self-rated health and mental health measured by the GHQ-scale) were examined using logistic regression models, adjusting for covariates at baseline.

**Results:** Participants living in an overcrowded dwelling (more than one person per room) at baseline were more likely to report poor self-rated health at follow-up (OR 1.45; 95% CI 1.08; 1.94) compared to those not living in an overcrowded dwelling. Additionally, participants who lived alone at baseline were more likely (OR 1.98; 95% CI 1.09; 3.58) to experience poor mental health at follow-up compared to those who lived with children.

**Conclusion:** Results indicate that household conditions are related to health in Greenland.

Public health authorities should work to ensure affordable housing of good quality in all communities.

**Keywords:** Indigenous health, Crowding, Household composition, Self-rated health, Mental health, Greenland.

## Background

In Greenland large households have, historically, been accommodated in small dwellings, but despite improvements in dwelling size and quality, poor housing conditions and especially overcrowding remain a public health concern<sup>1</sup>.

Most studies concerning household crowding and health among the Inuit in Greenland have focused on respiratory diseases as shared physical proximity is associated with the spread of infectious and chronic respiratory diseases<sup>2</sup>. Household overcrowding, has been associated with increased prevalence of tuberculosis, especially among children in the population<sup>3,4</sup> and the prevalence of lower respiratory tract infections (LRTI) and hospitalizations due to LRTI are higher among Inuit infants and children living in more crowded households<sup>5,6</sup>. In other Arctic populations overcrowding has been associated with more general measures of health. Among Inuit and First Nation children in Canada, household overcrowding was found to be associated with poor parent-rated child health<sup>7,8</sup> and housing improvements have been shown to improve self-perceived health status, well-being and quality of life<sup>9</sup>. Similar associations between household overcrowding and general measures of health have not, to our knowledge been investigated recently among Inuit in Greenland.

In several international studies, household overcrowding has been associated with poor mental health and is often described as a stressor, eliciting poor mental health responses<sup>10</sup>. Living in an overcrowded household has been associated with poor mental wellness among Inuit youth<sup>11</sup> and poor physical and poor mental health among Inuit children before adjustments for socio-demographic and socioeconomic factors<sup>7</sup>. A single cross-sectional study investigated the association between household overcrowding and well-being among Greenlandic Inuit; results showed that the risk of reporting depressive symptoms was higher among participants living in crowded households<sup>1</sup>.

The above-mentioned studies have all been cross-sectional, few have investigated the association in a longitudinal study design. A study among 11,500 households in New Zealand examined the impact of housing factors (household tenure, household crowding and housing affordability) on psychological distress cross-sectionally and longitudinally. They found a strong cross-sectional association, but the longitudinal analysis showed little or no effect. A recent study among Inuit adolescents in Nunavik investigated the association between household overcrowding in childhood and psychological distress in adolescents; the results showed no longitudinal or cross-sectional effect<sup>12</sup>. The authors explain the non-conclusive results by the instability of the exposure and that the composition of the household was not considered in the study. Research indicate that the composition of the household might be an important risk factor for health. A study among young Sami in Sweden found elevated odds of feeling healthy, sleeping well and feeling calm among persons who lived with others while the odds of having negative feelings like worries and sadness was twice as high among persons who lived alone<sup>13</sup>.

Knowledge about the impact of housing conditions on self-rated health (SRH) and mental health among the Inuit in Greenland are limited. Previous studies in the population are cross-sectional and recommend the association to be further investigated in a longitudinal study design.

*Aims:*

The objective of this study is to investigate the association between household crowding and household composition and SRH and mental health among an Inuit cohort in Greenland.

We hypothesize, based on previous findings in the population, that living in an overcrowded dwelling in 2005-10 is associated with poor mental health and poor SRH in 2014. Additionally,

it is expected that living alone in 2005-2010 is associated with both poor mental health and poor SRH in 2014.

## Methods:

### *Greenland*

Greenland, or Kalaallit Nunaat “Land of the Greenlandic People”, has a population of 55,877 of whom 90% are ethnic Greenlanders (Inuit). 87% live in towns, 12 % in villages, and about 1% are living in smaller settlements<sup>14</sup>. Greenland was under Danish colonial rule, a process which started in 1721 and ended in 1953, Home Rule was instated in 1979, and Self Government in 2009.

During the post-colonial years, profound changes took place in Greenland and modern houses with running water and bathrooms were built to replace the traditional stone-and-turf houses<sup>15</sup>. Housing conditions have improved but still vary and is a health concern especially in the villages, where housing conditions are poorest<sup>16</sup>. The 1990’s housing surveys showed that 50% of people living in towns and 72% of people in villages complained about cold dwellings and especially cold floors. Furthermore, 20% of all houses in villages were in need of major repair, and another 20% were beyond repair<sup>16, 17</sup>. To our knowledge more recent housing surveys have not been conducted in Greenland.

### *Sample*

A cohort of 1282 Inuit adults ( $\geq 18$  years old) was constructed based on two population-surveys. The Inuit Health in Transition survey 2005-2010 (IHIT)<sup>18</sup> (baseline) and the Health Survey in Greenland 2014 (B2014)<sup>19</sup> (follow-up). Cohort participants took part in both surveys, lived in

Greenland at the time of the surveys, and were born in either Greenland or Denmark. Participants were included in the cohort if they identified themselves as Greenlandic in either survey. The cohort inclusion process is shown in Fig. 1.

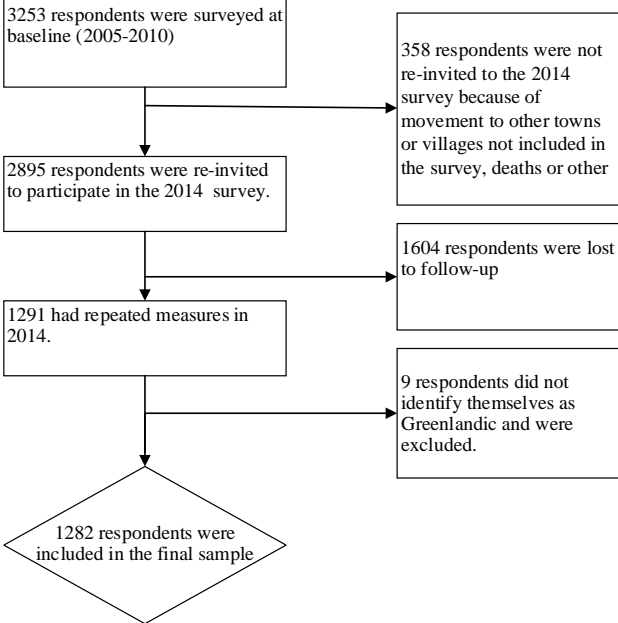


Fig. 1: Cohort inclusion process between the baseline (Inuit health in transition Greenland survey, 2005-10) and follow-up survey (The health survey in Greenland, 2014).

*Baseline data: The Inuit Health in Transition survey*

The Inuit health in transition survey (IHIT) is a cross-sectional population-based survey conducted from 2005 to 2010 among Inuit in Greenland. A full description of the study is available elsewhere<sup>18</sup>. Survey participants were recruited through a stratified random sample of adults (≥18 years). Greenland was divided into strata based on geography and community size. In each stratum or region, several towns and villages were selected as being representative of the region regarding living conditions. In each town, a random sample of 11-22% of the adult population was drawn from the central population register to obtain around 300 participants. In the selected villages, all adults were invited to participate<sup>18</sup>. A total 3253 persons from 22 communities

participated in the survey for a participation rate of 68%. Nine percent of the adults living in Greenland were included in the IHIT survey<sup>18</sup>. Two survey questionnaires were used for data collection: (1) an interviewer-administered survey and (2) a self-administered survey questionnaire containing sensitive questions about suicide, alcohol and marihuana consumption, sexual abuse and gambling<sup>18</sup>. Interviews were administered in Greenlandic or Danish and were conducted by native Greenlandic speaking interviewers.

#### *Follow-up data: The Health Survey in Greenland 2014*

The Health Survey in Greenland 2014 (B2014) is a cross sectional population-based survey conducted in 2014. A full description of the study is available elsewhere<sup>19</sup>. The survey was designed as a follow-up of the IHIT survey and included participants from previous population-based surveys in Greenland (1993-94, 1999-2001, 2005-2010) and a new randomly drawn sample from the central person register of individuals between 18-25 years old. For logistic reasons, settlements and towns with an expected number of participants of fewer than 25 in settlements and fewer than 60 in towns, were excluded from the overall sample. Data was collected similarly to the IHIT survey protocol. A total of 2102 people participated (participation rate of 63%) of whom 1862 (89%) answered the self-administrated questionnaire<sup>19</sup>.

#### *Ethics*

Both surveys were approved by the Scientific Ethics Committee in Greenland. All participants were informed orally about the content and process of the survey and signed an informed consent form<sup>18, 19</sup>.



### *Health outcomes*

SRH was assessed by asking respondents at both times: “In general would you say your health is?”. SRH was analysed as a dichotomous measure contrasting those reporting very good or good health, vs. those reporting moderate, bad or very bad health<sup>19</sup>.

In 2014, mental health was assessed using the 12-item General Health Questionnaire (GHQ) in the self-administered survey. The GHQ is a self-administered screening tool designed to detect current mental disturbances and disorders<sup>20</sup>. At follow-up participants reported the frequency of having felt 12 feelings such as: Useful, unhappiness and worthlessness in the two preceding the interview. Each of the 12 items were rated on a four-point scale (less than usual, no more than usual, rather more than usual, or much more than usual) obtaining a point when experiencing negative symptoms rather more than usual or much more than usual, and when experiencing positive symptoms less than usual or no more than usual, creating a scale ranging from 0-12. The GHQ scale was analysed as a dichotomous measure, a cut-off at  $\geq 3$  identifies individuals with poor mental health.

### *Overcrowding and household composition*

Household overcrowding was measured as the number of persons per room (PPR) - the ratio between the number of persons and the number of rooms in their dwelling. At baseline, respondents reported the number of persons (adults + children) living in the dwelling and the number of rooms (all rooms except the kitchen, bathroom and entrance hall). However, in other studies in Arctic regions, the number of rooms also counts the kitchen. An extra room have therefore been added to the room count, to make the indicator comparable to other studies in the Arctic<sup>1, 21</sup>.

Different variables for overcrowding were included in the analyses, as it is an on-going discussion how to measure overcrowding and which threshold to use when identifying overcrowded dwellings in indigenous populations<sup>22</sup>. The PPR measure was included in the analyses as a continuous and as a dichotomous variable. The dichotomous variable contrasts participants living in a dwelling with more than one person per room and hence deemed overcrowded, to those who were not. The number of persons in the household (adults + children) were also included in the analyses to investigate this aspect independent of the number of rooms.

The composition of the household was included separately as living arrangements might influence health<sup>1,13</sup>. Household composition was included as a categorical variable with three levels: households with children, adult-only households, and single-person households.

### *Covariates*

Covariates were all defined in 2005-10. Information about sex and age was derived from the participant's civil registration number.

Research has shown that a continuous measure of ownership of household items is a good proxy for socioeconomic position in Greenland<sup>23</sup>. Respondents were asked about ownership of any of the following items: Video/DVD player, computer, phone (landline), refrigerator, microwave, washing machine or dishwasher. Household assets was calculated as the sum of these items.

In the IHIT survey the GHQ scale was not included in the questionnaire. Alternatively, participants reported whether they had been bothered in the two weeks preceding the interview by: (a) anxiety, nervousness, agitation or fear; or (b) feeling depressed or unhappy. A categorical

variable was constructed to reflect the participants' mental health status at baseline with three levels: "No anxiety or depressive symptoms", "have been bothered by symptoms of anxiety and/or depression" or "have been severely bothered by symptoms of anxiety and/or depression".

### *Statistical analysis*

Descriptive statistics are presented for the full sample. Associations between housing condition and each health outcome were tested in separate logistic regression models for each main exposure variables and adjusted for covariates (identified via Directed Acyclic Graphs) and time to follow-up. Analyses were conducted on a subsample of data without missing information on individual covariates, the sample therefore varies by health outcome. In the logistic model comparing participants living in an overcrowded dwelling vs. participants not living in an overcrowded dwelling at baseline, participants who were living alone at baseline were excluded from the analyses to make the two groups more comparable and avoid confounding bias (as health of those living alone, and therefore not living in overcrowded conditions, might be different from those who are not living alone due to the loss of a spouse, divorce etc.).

To investigate possible non-random selection into the cohort, baseline characteristics between those included in the cohort were compared to those lost to follow-up (Table 4).

In 2014, 20% of the participants were living in the same household. To adjust for the clustering effect, the standard errors were clustered in households. Household clusters were identified using the participant's household number, derived through information about the participants address. All statistical analyses were performed using the Stata SE software version 14.0<sup>24</sup>.

## Results

Descriptive statistics of the participants at baseline and follow-up are shown in Table 1.

Table 1 – Characteristics of the 1282 participants at baseline (Inuit health in transition survey, 2005-10) and follow-up (The health survey in Greenland, 2014).

	Baseline (2005-10)	Follow-up (2014)	P-values <sup>a</sup>
<b>Individual Characteristics</b>			
<i>Self-rated health [n (%)]</i>			<0.001
Good	847 (66.1)	732 (57.1)	
Poor	433 (33.7)	531 (41.4)	
Missing [n (%)]	2 (0.2)	19 (1.5)	
<i>Mental health [n (%)]</i>			
Good mental health (GHQ <3)		806 (62.9)	
Poor mental health (GHQ ≥3)		192 (15.0)	
Missing [n (%)]		284 (22.1)	
<i>Mental health [n (%)]</i>			<0.001
No anxiety or depressive symptoms	683 (53.3)	792 (61.8)	
Have been bothered by symptom of anxiety and/or depression	537 (41.9)	399 (31.2)	
Have been severely bothered by symptom of anxiety and/or depression	62 (4.8)	91 (7.0)	
<i>Sex [n (%)]</i>			
Men	480 (37.4)		
Women	802 (62.6)		
<i>Age</i>			<0.001
Mean (SD)	42.9 (12.9)	50.5 (13.0)	
Median; range	43; 18-89	50; 23-97	
<b>Household characteristics</b>			
<i>Region [n (%)]</i>			<0.001
South	233 (18.2)	226 (17.6)	
Central	421 (32.8)	462 (36.0)	
North	437 (34.1)	417 (32.5)	
East	183 (14.3)	177 (13.8)	
Avanersuaq	8 (0.6)	-	
<i>Community type [n (%)]</i>			<0.001
Village	279 (21.8)	226 (17.6)	
Town	785 (61.2)	783 (61.1)	
Nuuk	218 (17.0)	273 (21.3)	
<i>Household assets</i>			<0.001
Mean (SD)	4.5(1.7)	4.7 (1.7)	
Median; range	5; 0-7	5; 0-7	
Missing [n (%)]	6 (0.47)	19 (1.5)	
<i>Household size (adults + children)</i>			<0.001
Mean (SD)	3.6 (2.2)	3.2 (1.8)	
Median; range	3; 1-18	3; 1-11	
Missing [n (%)]	5 (0.4)	26 (2.0)	
<i>Number of persons pr. room</i>			<0.001
Mean (SD)	0.9 (0.6)	0.8 (0.4)	
Median; range	0.8; 0.1-4.5	0.7; 0.1-4.5	
Missing [n (%)]	5 (0.4)	26 (2.0)	
<i>Overcrowded households (more than one person per room) [n (%)]</i>			<0.001
Not overcrowded	993 (77.5)	1029 (80.3)	

Overcrowded	284 (22.5)	227 (17..7)	
Missing [n (%)]	5 (0.4)	26 (2.0)	
<hr/>			
<i>Household composition [n (%)]</i>			<0.001
Households with children <sup>a</sup>	742 (57.9)	567 (44.2)	
Adult only households (≥2 adults)	405 (31.6)	516 (40.2)	
One-person households	130 (10.1)	173 (13.5)	
Missing	5 (0.4)	26 (2.0)	

<sup>a</sup> Based on paired t-test for continuous measures and chi2 for categorical measures

Forty-one percent reported poor SRH in 2014; an increase since baseline (34%). Fifteen percent experienced poor mental health in 2014, but 24% (n=284) of the participants had missing data on the GHQ-scale; this was due to the low response rate in the self-administered questionnaire in the B2014 survey. In 2005-2010, 42% reported symptoms of either anxiety or depression and 5% reported severe symptoms. Women were overrepresented in the cohort (63%) and the average age in 2005-10 was 43 years. At both times, most of the population were living on the central west coast and in towns. During follow-up, the participant's access to specific assets had increased from 4.5 on average at baseline to 4.7 at follow-up. Household size had decreased during follow-up (from 3.6 persons to 3.2); resulting in fewer participants living in crowded conditions (23% at baseline, 18% at follow-up). The youngest age groups were more likely to live in overcrowded dwellings and more participants lived alone at follow-up, with men and participants among older age groups overrepresented in this group (results not tabulated).

#### *Self-rated health and household overcrowding and composition*

Results of the association between housing conditions in 2005-10 (i.e. household overcrowding and composition) and SRH in 2014 are presented in Table 2. Household size and overcrowding in 2005-10 (measured as the number of persons per room categorically and continuously) are statistically associated with elevated odds of poor SRH in 2014, in the fully adjusted model. No association was observed between household composition in 2005-10 and poor SRH in 2014.

Table 2–The association between baseline housing conditions (Inuit health in transition Greenland survey, 2005-10) and poor self-rated health at follow-up (The health survey in Greenland, 2014)\*\*.

<i>n</i> =1251	n (%)	Model 1 Unadjusted		Model 2 <sup>b</sup>	
		OR	95% CI	OR	95% CI
<i>Number of persons living in dwelling (adults + children)</i>	†	1.06	[1.01; 1.12]*	1.06	[1.00; 1.12]*
<i>Number of persons pr. room</i>	µ	1.36	[1.11; 1.66]*	1.27	[1.02; 1.60]*
<i>Crowding status<sup>a</sup></i>					
Not overcrowded	844 (75.16)	1.00		1.00	
Overcrowded	279 (24.84)	1.55	[1.17; 2.04]*	1.45	[1.08; 1.94]*
<i>Household composition</i>					
Households with children	725 (57.86)	1.00		1.00	
Adult only households (≥2 adults)	398 (31.76)	0.97	[0.75; 1.25]	0.94	[0.71; 1.24]
One person households	130 (10.38)	0.92	[0.63; 1.35]	0.85	[0.56; 1.29]

† mean 3.62; SD 2.20; 6 missing at baseline

µ mean 0.90; SD 0.55; 6 missing at baseline

<sup>a</sup> one-person households are excluded from the analysis

<sup>b</sup> adjusted for individual characteristics (age, sex, household assets, self-rated health at baseline) and time to follow-up.

\**p* < 0.05

\*\* Based on logistic regression analyses.

### *Mental health and household overcrowding and composition*

The associations between housing conditions in 2005-10 and mental health in 2014 are presented in Table 3. The results showed no statistical association between household crowding in 2005-10 and poor mental health in 2014. Living alone in 2005-10 was found to be statistically associated with poor mental health in 2014. Estimates in the two models changes noticeably after the adjustment for covariates, especially after the adjustments for age (results not tabulated), suggesting that age is a confounding factor in the association between housing conditions and mental health.

Table 3 – The association between baseline housing conditions (Inuit health in transition Greenland survey, 2005-10) and poor mental health at follow-up, GHQ cut-off at  $\geq 3$  (The health survey in Greenland, 2014)\*\*.

<i>n</i> =972	n (%)	Model 1 Unadjusted		Model 2 <sup>b</sup>	
		OR	95% CI	OR	95% CI
<i>Number of persons living in dwelling (adults + children)</i>	†	1.05	[0.97; 1.12]	0.98	[0.91; 1.06]
<i>Number of persons pr. room</i>	μ	1.28	[0.97; 1.69]	0.97	[0.71; 1.33]
<i>Crowding status<sup>a</sup></i>					
Not overcrowded	696 (76.40)	1.00		1.00	
Overcrowded	215 (23.60)	1.11	[0.75; 1.65]	0.71	[0.45; 1.]
<i>Household composition</i>					
Households with children	620 (62.31)	1.00		1.00	
Adult only households (>=2 adults)	289 (29.25)	0.90	[0.63; 1.30]	1.28	[0.86; 1.90]
One person households	83 (8.44)	1.39	[0.81; 2.38]	1.98	[1.09.; 3.58]*

† mean 3.62; SD 2.19; 3 missing at baseline

μ mean 0.89; SD 0.55; 3 missing at baseline

<sup>a</sup> one-person households are excluded from the analysis

<sup>b</sup> adjusted for individual characteristics (age, sex, household assets, mental health at baseline) and time to follow-up.

\**p* < 0.05

\*\* Based on logistic regression analyses.

Table 4 Baseline characteristics of the cohort participants (*n*=1282) compared to baseline characteristics of the participants who were lost to follow-up (*n*=1962) (Inuit health in transition survey, 2005-10).

	Cohort Participants	Participants lost to follow-up	<b>P-value<sup>a</sup></b>
<b>Individual Characteristics</b>			
<i>Self-rated health [n (%)]</i>			0.14
Good	847 (66.1)	1240 (63.2)	
Poor	433 (33.8)	709 (36.1)	
Missing [n (%)]	2 (0.2)	13(0.7)	
<i>Anxiety within the two preceding weeks [n (%)]</i>			0.002
Yes	443 (34.6)	573 (29.2)	
No	838 (65.4)	1382 (70.4)	
Missing [n (%)]	1 (0.1)	7 (0.4)	
<i>Depressed within the two preceding weeks [n (%)]</i>			0.10
Yes	387 (30.2)	539 (27.5)	
No	890 (69.4)	1412 (72.0)	
Missing [n (%)]	6 (0.5)	11 (0.6)	
<i>Sex [n (%)]</i>			<0.001
Men	480(37.5)	988 (50.4)	
Women	802(62.6)	974 (49.6)	
<i>Age</i>			<0.001
Mean (SD)	42.9 (12.9)	45.6 (15.8)	
Median; range	43; 18-89	45; 18-95	
<b>Household characteristics</b>			
<i>Region [n (%)]</i>			<0.001

South	233 (18.2)	406 (20.7)	
Centre	421 (32.8)	700 (35.7)	
North	437 (34.1)	409 (20.8)	
East	183 (14.3)	170 (8.7)	
Avanersuaq	8 (0.6)	277 (14.1)	
<i>Community type [n (%)]</i>			0.37
Village	279 (21.8)	461 (23.5)	
Town	785 (61.2)	1195 (60.9)	
Nuuk	218 (17.0)	306 (15.6)	
<i>Household assets</i>			<0.001
Mean (SD)	4.5 (1.7)	4.20 (1.8)	
Median; range	5; 0-7	4;0-7	
Missing [n (%)]	6 (0.5)	5 (0.3)	
<i>Size (adults + children)</i>			<0.001
Mean (SD)	3.6 (2.2)	3.2 (2.0)	
Median; range	3; 1-18	3; 1-18	
Missing [n (%)]	4 (0.3)	14 (0.7)	
<i>Number of persons pr. room</i>			0.0003
Mean (SD)	0.9 (0.6)	0.8 (0.5)	
Median; range	0.8; 0.1-4.5	0.7; 0.2-4.7	
Missing [n (%)]	5 (0.4)	19 (1.0)	
<i>Overcrowded households (more than one person per room) [n (%)]</i>			0.04
Overcrowded	284 (22.2)	373 (19.0)	
Not overcrowded	993 (77.5)	1570 (80.0)	
Missing [n (%)]	5 (0.4)	19 (1.0)	
<i>Household composition [n (%)]</i>			<0.001
Households with children	742 (57.9)	900 (45.9)	
Adult only households ( $\geq 2$ adults)	405 (31.6)	698 (35.6)	
One-person households	130 (10.1)	350 (17.8)	
Missing	5 (0.4)	14 (0.7)	

<sup>a</sup> Based t-test for continuous measures and chi2 for categorical measures

## Discussion:

The objective of this study was to investigate the effect of household crowding and composition on SRH and mental health among a cohort of Inuit adults. The results showed that living in an overcrowded dwelling in 2005-10 was associated with poor SRH in 2014 and that living alone in 2005-10 was associated with poor mental health in 2014.

The findings support results from previous studies finding that poor housing conditions has a negative effect on health<sup>2, 9</sup> and that living alone has a negative effect on mental health<sup>13</sup>. No association was found between household composition and poor SRH in this study. Others have



observed that the association between social isolation and mortality was mediated through social support, which often has been associated with mental well-being<sup>25</sup>. This suggests that household composition might be more important for mental health than for SRH.

No association was found between household overcrowding in 2005-10 and poor mental health in 2014. Existing literature has noted a cross-sectional association between increased psychological distress and poor housing conditions in the population<sup>1</sup>, but the discrepancy could be explained by the study design as the current study is the first to investigate the association between housing and health in an Inuit cohort in Greenland and therefore attempting to rule out health selection. In their New Zealand study (not focusing on an indigenous population), the authors observed a strong cross-sectional association between housing factors and psychological distress, but the longitudinal analysis showed little or no effect<sup>26</sup>. The authors conclude that the findings of the cross-sectional analysis are confounded and that the role of housing conditions on psychological distress is not as straightforward as cross-sectional studies might imply<sup>27</sup>. The results in the current study are in accordance with the findings by Pepin, Muckle<sup>12</sup>, who found no association between childhood household overcrowding and psychological distress in adolescents. Neither of the studies investigated the effect of household composition on mental health. This discrepancy from previous cross-sectional results might be explained by different measures of mental health. In this study mental health was assessed by the GHQ-scale. Although we report results for the cut-off at 3, which is commonly used in general populations<sup>28</sup>, we considered a cut-off at 2 which has been previously validated in the Greenlandic population<sup>29</sup>. The association between these two cut-offs and other indicators for poor mental health (e.g., suicidal ideations) was investigated (results not tabulated). Because the results showed the strongest association between the cut-off at 3 and other indicators for poor mental health, this cut-off was retained in the analyses. It is recommended to revalidate the scale.

Twenty-two percent of the participants had not completed the GHQ-questionnaire. These participants reported depressive symptoms more often, were older, had poorer SRH and lower SES compared to those who answered the questionnaire. This could underestimate the results as the included participants might have better mental health than the original population.

Overcrowding was measured as the number of persons per room (overcrowded dwellings were defined as >1 person per room). The results showed only minor variation between the different measures of overcrowding (see table 2). Overcrowding was measured at one point in time and may therefore represent a single snapshot of living conditions, which may not represent the experience of living in an overcrowded dwelling over the study period. It might be argued that housing conditions would not change on a regular basis, but because hidden homelessness is an issue in Arctic regions (people who are staying with relatives, friends, neighbors or strangers because they have no other options) the number of people in the dwelling might change frequently<sup>21</sup>.

Our findings should be considered in the light of the study's limitations. The results of this study might be influenced by selection bias as 60 % of the baseline population were lost to follow-up. Results of the comparison of baseline characteristics between those included in the cohort and those lost to follow-up show that the selection was not random (Table 4). In general, participants included in the cohort were younger, female, had access to more household assets, and lived in bigger households than those who were lost to follow-up. We did not observe baseline differences in SRH between cohort participants and those lost to follow-up, but differences were observed in symptoms of anxiety, where cohort participants experienced anxiety symptoms more often than those who were lost to follow-up. This selection can result in an overestimation of the results. However, it is uncertain if the mental health measures at baseline

are a robust indicator for mental health at follow-up. A previous study did show that the prevalence of reporting anxiety and depression, were significantly higher among people scoring  $\geq 2$  on the GHQ-scale<sup>30</sup>. The possible issues with the mental health measure at baseline could lead to residual confounding as mental health in 2005-10 may not be adequately adjusted for in the analyses.

## Conclusions

This study, the first among an Inuit cohort in Greenland, confirms that living in an overcrowded dwelling is associated with poor SRH, but the effect of overcrowding on mental health might be more complicated than first assumed. The findings show that household composition is an important factor to consider regarding mental health. Policymakers should consider housing conditions in health-related policies to improve public health in Greenland.

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