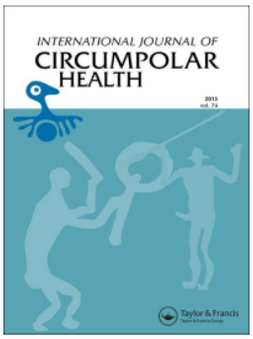

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THEORY AND METHODS ARTICLE

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The Greenland population health survey 2018 – methods of a prospective study of risk factors for lifestyle related diseases and social determinants of health amongst Inuit

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ABSTRACT

Since 1993, regular population health surveys in Greenland have supported and monitored the public health strategy of Greenland and have monitored cardiometabolic and lung diseases. The most recent of these surveys included 2539 persons aged 15+ from 20 communities spread over the whole country. The survey instruments included personal interviews, self-administered questionnaires, blood sampling, anthropometric measurements, blood pressure, ECG, oral glucose test, pulmonary function, hand grip strength and chair stand test. Blood samples were analysed for glucose, glycated haemoglobin (HbA1c), insulin, incretin hormones, cholesterol, kidney function, fatty acids in erythrocyte membranes and mercury, urine for albumin-creatinine ratio, and aliquots were stored at −80°C for future use. Data were furthermore collected for studies of the gut microbiome and diabetes complications. Survey participants were followed up with register data. The potential of the study is to contribute to the continued monitoring of risk factors and health conditions as part of Greenland's public health strategy and to study the epidemiology of cardiometabolic diseases and other chronic diseases and behavioural risk factors. The next population health survey is planned for 2024. The emphasis of the article is on the methods of the study and results will be presented in other publications.

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Inuit; Greenland; social determinants; cardiometabolic diseases; airway diseases; risk factors; population health survey

Public health priorities in Greenland

Public health priorities in Greenland from 2013 to 2019 were defined by the public health strategy *Inuuneritta II* which was defined by the government of Greenland and endorsed by the Greenland parliament. The government and parliament of Greenland is elected by all citizens of Greenland and represent the Inuit people. Inuuneritta II covered four major topics for public health in Greenland i.e.: 1) Harmful use of alcohol and cannabis; 2) Use of tobacco; 3) Physical activity and 4) diet. Health promoting initiatives and interventions were intended to target children, youth and families. Furthermore, social inequality in health was an overarching theme for the strategy. Each topic was designated a year with extra resources for launch and implementation of projects and interventions. The Greenland Population Health Survey 2018 was planned to evaluate prevalence and development at the adult population level within the four topic areas that all represent major public health challenges for/in Greenland.

Previous population health surveys

The population health survey in Greenland in 2018 is number five in a series of countrywide population health surveys in 1993 (N = 1728), 1999 (N = 2001), 2005 (N = 3253) and 2014 (N = 2188). The first study was initiated by the Department of Health in Greenland and the second by researchers from Danish universities. From 2005, the surveys were conducted in collaboration between the Department of Health in Greenland, the National Institute of Public Health in Denmark and Steno Diabetes Center in Denmark. From 2014 the

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funding for the interviews was provided by the Department of Health in Greenland whereas funding for the clinical part of the surveys was provided from a number of public and private research foundations. Results were primarily reported to the Department of Health in Greenland and later in peer-reviewed scientific journals [1,2]. The data are administered by the National Institute of Public Health at the University of Southern Denmark on mandate by the government of Greenland. Only the researchers at the National Institute of Public Health have direct access to individual-level data.

Except in the first study, interviews about lifestyle, living conditions, risk factors and disease were combined with selected clinical examinations and sampling of biological media. Earlier studies focused on multiple health issues, including social determinants of (mental) health, suicidal behaviour, diet and contaminants, use of alcohol, tobacco and gambling, physical activity as well as studies of the health services. A series of reports to the Health Department of the Government of Greenland have monitored major population health issues such as social inequity in health, sexual violence, suicides, alcohol, smoking, diet and physical activity. The previous population surveys in Greenland have also focused on common lifestyle-related diseases, aiming to address health effects of changes in diet and physical activity. The focus has been on obesity, diabetes, cardiovascular disease, and pulmonary function. Greenlanders residing in Denmark have been studied using the same methodology.

Among the many research topics published with data from the population health surveys in Greenland we would like to highlight the following:

Social inequality in health among regions in Greenland and among individuals is a major public health issue in Greenland. We have found post-colonial stress and high alcohol consumption to be associated with adverse childhood experiences such as sexual assault and domestic violence. Our research has further demonstrated how these adversities are strongly associated with suicidal thoughts later in life, especially among youth [1]. In addition to traditional western markers for social position based on income, education and wealth we have developed culturally relevant markers for social position among the Inuit, but these require further development [3]. Greenlanders are in the midst of a transition from village life as hunters/fishermen to life as urban white-collar employees which involves a potential for declining mental health and well-being, but rapid societal development is in itself not necessarily a cause of poor mental health: as a result of an improvement in living conditions in especially larger communities and the capital, some population groups have better mental health compared to other groups [4]. The Gini coefficient which is a measure of economic inequality has increased from 33.0 in 2002 to 35.4 in 2018 indicating an economically increasingly unequal society [5].

We have developed a food frequency questionnaire for use in Greenland with questions about locally harvested and imported food and have shown a rapid change of dietary patterns: the consumption of marine mammals decreased whereas the consumption of locally caught fish remained stable, and the consumption of imported food increased with an increased intake of dietary fibres, fruit, and vegetables, but also energy-dense foods and refined sugar. This happened parallel to a rapidly increasing prevalence of overweight and obesity with 24% and 30% of men and women being obese in 2014 compared to 13% and 12% in 1993 [6–8]. A question about food insecurity was added in 2014 and in 2018 three questions were applied.

In two studies in 1999–2001 and 2005–2010 we found a notably high prevalence of diabetes with approximately 9% of the adult population being identified with diabetes, and additionally 25–30% had prediabetes defined as impaired glucose tolerance or impaired fasting glycaemia [9,10]. Studies conducted in Greenland in 1999–2002 and in 2011–2012 have documented that the incidence of cardiovascular disease in Greenland is comparable to European populations [11,12], but it is unknown whether there has been a further increase in cardiometabolic diseases and their risk factors. The Greenlandic Inuit people have been historically isolated and have unique genetic backgrounds, and based on data from previous population surveys in 1999–2001, 2005–2010 and 2013 a strong genetic predisposition to several cardiometabolic conditions and loci showing evidence of genetic adaptation to diet and climate was demonstrated [13–16].

The primary aims of this study were to monitor time trends and risk factors for the population health issues included in Inuuneritta II and selected chronic diseases (diabetes, hypertension, obesity, lung function, airway diseases), to study social and behavioural risk mechanisms for selected health outcomes such as mental health and suicidal behaviour, obesity, diabetes and activities of daily living and to explore cultural and social determinants for health and well-being. The emphasis of the present article is on the methods of the study and results will be presented in other publications.

Methods

Population and sample

Data were collected from 2016 to 2019 as part of a countrywide cross-sectional health survey in

Greenland (Figure 1). The participants, aged 15 years and older, were selected through a stratified random sample of adults in Greenland, who had been born in Greenland or Denmark. From each of five strata defined according to geographical criteria (South, Mid, Northwest, North and East Greenland), 20 towns and villages were chosen at random. From 12 towns, a random sample of inhabitants aged 15+ years were invited and from 8 villages all inhabitants were invited to participate in the study. The participation rate was 52%. Questionnaires were developed in the Danish language, translated into Greenlandic (*kalaallisut*), back-translated and revised. Interviews were conducted in the participant's language of choice, which was most often Greenlandic, by native Greenlandic speaking interviewers. Inuit ethnicity was defined at enrolment from the primary language and self-identification of the participants. A total of 2539 persons participated in the study of which 2436 (96%) were classified as Inuit. The sample was designed to allow a reasonably precise estimate (± 1.5–2.0%) of common health parameters at the national level and to allow some geographical comparisons in particular among the five municipalities and between towns and villages. The sample size and number of participants was limited by the resources available and a lower-than-expected participation rate.

Data collection

Interviews and clinical examinations were conducted locally at schools, health centres or other available facilities. The health care centres, the regional administration and the health administration were informed about the survey in advance. All communities were visited by public transportation (airplane) or a chartered boat. The boat was used to reach communities with poor public transportation considering the volume of equipment needed. The chartered boat (M/V Kisaq, a 27 m ice-strengthened expedition vessel) was able to sail under almost all weather conditions and has accommodation for 12 passengers as well as large volumes of equipment. It is an unambiguously more convenient alternative to public transport, chartered helicopter or local boat charter. The mean duration of the total examination for a participant, was 2.5 hours including interview and clinical examination. Invitation to participate in the survey was sent as a personally addressed letter. Those asked to participate were

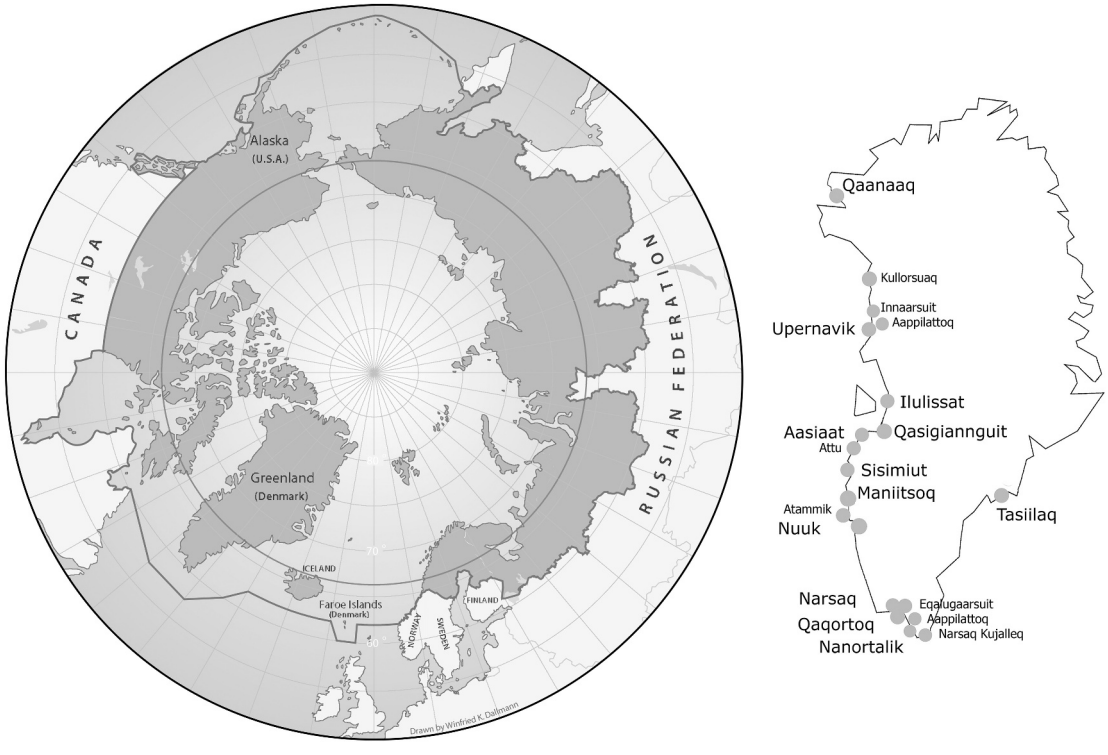

Figure 1. Greenland and communities where data collection took place during 2016–2019. The grey shading of the circumpolar map indicates Arctic states and regions according to Arctic Council. Circumpolar map by Winfried Dallmann, Norwegian Polar Centre.

invited to accept by email, letter or text message. All individuals were also contacted by phone by the person in charge of recruitment. Recruitment was a major challenge and sometimes prospective participants were called on the phone multiple times or visited in their home. The leadership at the health centres and at the regional and central health care administration were informed in writing before the survey started. Information about the survey was communicated locally on posters, via local and national television and radio. Additionally, a Facebook page was created, where the participants and other interested citizens could follow and comment on the study. Participants received an inexpensive neckwear (a buff) as a small token of appreciation but no further financial incentives.

The interviewers were all Inuit who were fluent in the Greenlandic language. Four interviewers were permanent staff who were extensively trained in the interview procedures prior to data collection. Twenty-two percent of the interviews were conducted by local, temporary staff who were instructed in the interview procedures as part of their short-term employment. Clinical assistants mostly performed one or a few clinical procedures and were trained by the researchers in charge of these particular procedures. Certified laboratory technicians collected and treated blood samples.

Questionnaires

The survey consisted of four questionnaires: an interviewer administered core questionnaire and a self-administered questionnaire given to all participants; a supplementary questionnaire for youth and young adults aged 15–34; and a supplementary questionnaire for older adults aged 55 + . The self-administered questionnaire had 91 questions. The interviews for youth and young adults had 294 questions, for middle-aged participants (the core questionnaire) 252 questions and for older adults 305 questions. The duration of the interview was 45 minutes for young and middle-aged participants and 55 minutes for older adults.

The core questionnaire contained 252 questions about social and socioeconomic conditions, childhood and smoking. Ethnicity was assessed at the beginning of the interview by the interviewer and the interviewee, and questions were later asked about self-perceived ethnicity, place of birth of the parents, ethnicity of parents and grandparents and proficiency in Greenlandic and Danish language. Material wealth was assessed by questions about ownership of ten household items (video/DVD player, computer, refrigerator, freezer, microwave oven, washing machine, dishwashing machine, internet, car/ATV, boat). Answers were combined to make up a household asset score which is an indicator of social position that is closely associated with more traditional measures of socioeconomic position, such as education and income, but has certain practical advantages and is often used in a Greenlandic context [3,17].

The interview included a 47-item quantitative food frequency questionnaire (FFQ) with 13 locally harvested and 34 imported food items. Interviewers were instructed to ask about typical food intake during the last 12 months. The frequency of consumption was reported as the (open-ended) number of times per day, week, month, or year. For each food item, one of four portion sizes was selected (fractions were allowed). The questionnaire was developed specifically for the use in the population health surveys in Greenland. From a smaller FFQ used in 1993, we have subsequently added food items and then deleted those that were consumed infrequently. The typical food items consumed in Greenland were determined by qualitative interviews with Greenlanders from different locations. Previous versions of the FFQ were validated by 24-hours dietary interviews and blood mercury analyses in the Disko Bay area [18] and by biomarkers in a countrywide sample of Greenlanders [19], especially for the consumption of locally harvested food. A validation of the current FFQ by food diary and biomarkers is being conducted for the next population health survey.

Three questions about the meal situation were included, namely “How often do you eat a main meal from your own catch or that of a family member?”, “How often do you eat a hot meal?” and “How often do you have dinner with your whole family (your household)?”. Also, three questions about food insecurity were included, namely “During the last 12 months, were there days when there was no food in the house and no money to buy food?”, “During the last 12 months, were there days when you went to bed hungry because of lack of food?” and “During the last 12 months, were there occasions when you had nothing to eat for 24 hours because of lack of food?” [20].

Information on physical activity was obtained from The International Physical Activity Questionnaire (IPAQ) (long version), which has previously been modified to arctic living conditions in Greenland with moderate validity [21]. The scoring system and calculation of physical activity energy expenditure and -intensity was done according to the IPAQ group guidelines [22]. Participants were asked whether they had ever been diagnosed with diabetes (including gestational diabetes), hypertension or cardiovascular disease. If yes, additional questions were asked regarding treatment.

Further questions were asked about family history of diabetes, obesity, hypertension and cardiovascular disease.

The self-administered questionnaire had 91 questions about issues that were considered sensitive such as mental health, substance use and gambling, suicides, sexual abuse and violence. Mental health was assessed by the 12-question version of Goldberg's General Health Questionnaire [23,24]. Questions on gambling were taken from the Lie/Bet as well as the NODS CLiP questionnaires [25,26]. Alcohol use was assessed by the AUDIT scale [27]. Questions on suicides, use of cannabis, sexual and physical violence were developed for the population health surveys in Greenland and have been used since 1993. Participants were asked about personal suicidal ideation and suicide attempts and about suicides among relatives and friends. Participants were further asked about alcohol problems in their childhood home, about personal exposure to sexual violence as a child (younger than 13 years), adolescent (13–17 years) and adult (18 years and older), and about being a victim of other forms of violence in the childhood home or as an adult.

A number of questions especially in the self-administered questionnaire were of a sensitive nature, such as questions about adverse childhood experiences and personal experience with suicide, which may elicit emotional reactions. Although no specific procedures were developed for referrals, the interviewers and the supervisor were trained to be alert to emotional reactions, but no professional counsellors were attached to the study. The interviewers were all Inuit with an intimate knowledge about the culture and community in Greenland and were aware of relevant helplines. In addition, the supervisor who welcomed the participants to the study and took leave of them after completion of the data collection had longstanding experience with the health care system in Greenland and could refer participants to the local health centre if needed due to emotional reactions or abnormal physical findings.

Our research interests have for many years included mental health among youth and young adults and the influence of adverse childhood experiences on adult health. It was therefore decided to expand the core questionnaire with 42 new questions directed at participants aged 15–34 years. The questions included both protective factors and risk factors for mental health. The following measurement scales of mental health were applied: Life satisfaction (Cantril's ladder) [28], self-esteem [29], self-efficacy [30], well-being (SWEMWBS) [31], loneliness and signs of mental illness (Kessler 6) [32]. Questions to youth and young adults also contained questions about plans for the future (education and plans for moving to a different community). Additionally, questions were added about social media use and cultural activities and connectedness to elders and culture, all comparable to questions in a similar survey conducted among Inuit in Nunavik [33].

In 2018 special interest was taken in the study of health and living conditions of older adults. A series of 53 questions for adults aged 55+ was developed in cooperation with the Danish Center for Social Science Research (VIVE) and the University of Copenhagen as part of an interdisciplinary study of older adults in Greenland [34]. Older adults were interviewed with the core questionnaire and the self-administered questionnaire described above but additionally were asked about socioeconomic conditions, social network, activities of daily living, help with daily chores received and given, and general life satisfaction.

Clinical and biochemical measures

Anthropometrics were measured in all participants. Other clinical- and biochemical examinations were performed in participants aged 18 years and older. Participants aged 35 years and older were instructed to fast overnight.

Biochemical measures

Blood samples were drawn from the antecubital vein. Whole blood was allowed to clot. Samples for biochemical analysis of plasma glucose were collected in fluoride-heparin coated tubes, and samples for incretin hormone concentrations were from blood sampled in chilled EDTA coated tubes. Both were put on ice immediately following sampling. Samples were centrifuged shortly after collection for 10 minutes at 3000 rpm at 20°C, except for samples used for analysis of HbA_{1c} and serum insulin concentrations. Samples for analysis of serum insulin concentration were centrifuged 30 minutes after collection. Samples were stored at −20°C and shipped within 14 days for analysis or transferred at −20°C to bio a bank with an average transportation time of 5 days. A random single void urine sample was collected from each participant and samples were stored at 4°C or at room temperature until shipment.

Plasma glucose, total cholesterol, HDL cholesterol, triglycerides, serum creatinine, urine albumin and -creatinine were analysed by an enzymatic method (Vitros 5600, Ortho Clinical Diagnostics, USA). Serum insulin was analysed using electro-chemiluminescence immunoassay (Cobas e411, Roche Diagnostics, Switzerland). All above analyses were performed at the central laboratory at Steno Diabetes Center

Copenhagen. HbA1c was measured immediately after blood sampling using a monoclonal antibody agglutination reaction (DCA Vantage ®, Siemens Healthineers). Fatty acid composition of erythrocyte membranes was determined by gas chromatographic analyses at Centre de recherche du CHU de Québec-Université Laval, Québec, Québec, Canada [35,36]. Results were expressed as the relative percentage areas of total fatty acids.

Whole blood mercury was analysed at Centre de toxicologie du Québec/INSPQ by ICP-MS (Inductively coupled plasma mass spectrometry) with a detection limit of 0.5 nmol/Litre (https://www.inspq.qc.ca/ctq/repertoire-des-analyses).

Samples were stored in the Steno Diabetes Center Biobank for planned later analysis of genetics and for plasma glucagon, Glucagon Like Peptide 1, and Gastric Inhibitory Polypeptide concentrations. Additional samples were stored in a biobank for long-term storage for future analyses: 6 × 1 ml of EDTA-plasma, 6 × 1 ml of serum, and 3 × 1.8 ml of urine were stored at −80°C. The biobank is located at the Steno Diabetes Center Copenhagen.

Clinical examinations

Height and weight were measured with the participants wearing underwear. Height was measured to the nearest millimetre and weight to the nearest 100 g. Waist circumference was measured on the standing participant midway between the rib cage and the iliac crest, hip circumference at its maximum. Both were measured to the nearest 0.5 cm. Bio impedance and calculation of fat mass were performed on a leg-to-leg Tanita TBF-300 MA (Tanita Corporation, Tokyo, Japan). Fat mass was calculated as the total weight of fat from the internal algorithm of the device based on height, weight, sex, impedance and age. Fat-free mass (kg) was calculated as the total body mass minus fat mass.

Oral glucose tolerance test

After a minimum of 8 hours fasting participants aged 35 years and older without medical treatment for previously diagnosed diabetes had an oral glucose tolerance test. A solution with 75 grams glucose was administered orally and venous blood samples for assessment of plasma glucose, serum insulin and incretin hormone concentrations were drawn at 0, 30 and 120 min. Glucose tolerance was classified according to WHO criteria [37].

Renal function

Estimated glomerular filtration rate (eGFR) was calculated using serum creatinine values expressed as millilitres per minute and adjusted for mean body surface area of 1,73 m^2, age and sex according to the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) formula with CKD cut-off at eGFR < 60 ml/min/1.73 m^2. We used the 2012 KDIGO guidelines (Kidney Disease: Improving Global Outcomes) defining albuminuria as urine albumin creatinine ratio in a random spot urine > 30 mg/g [38].

Blood pressure

Blood pressure was measured at the right arm of the sitting participant after at least five minutes of initial rest. Blood pressure was measured at specified times during the interview with >5 minutes' interval using an automatic measuring device (Model UA-852 (A&D Instruments, Oxfordshire, UK)) with an appropriate size cuff. The blood pressure was read to the nearest mm Hg three times. The mean value of the two last measurements was used for the analyses.

ECG

The ECG was recorded in the supine position on a MAC15 digital ECG recorder (GE Medical Systems, Milwaukee, WI), with a standard 12-lead system at a sampling rate of 500 Hz and an amplitude resolution of 1.22 µV.

Pulmonary function

Pulmonary function tests were performed by EasyOne (NDD Medical Technologies, Switzerland). All tests were performed in standing position and without a nose clip; patients were instructed to exhale into a mouthpiece after inhalation to full capacity of the lungs – with at least two values of forced expiratory volume in 1 second (FEV1) within 5% variation. FEV1 and forced vital capacity (FVC) were measured. Predicted values were based on age and sex adjusted normative data [39,40]. In accordance with the Global Initiative for Asthma (GINA) guidelines [41] a FEV1/FVC below 80% – as well as a FEV1 below 80% of predicted value – was considered significantly abnormal and suggestive of possible asthma/obstructive pulmonary condition. At a FEV1/FVC below 70% participants were advised to see a doctor. All spirometry curves were post hoc analysed for misconduct, i.e. exhaling not fast in the beginning and throughout the entire

exhalation (too low FEV1) and furthermore, exhalation was terminated before emptying of the lungs was finalised (too low FVC).

Hand grip strength

Hand grip strength was measured by a SAEHAN DHD-1 digital hand dynamometer (SAEHAN Corporation, South Korea). The participant was seated at a table with the feet firmly placed on the ground, the elbow resting on the table and the forearm parallel with the table. The dynamometer was adjusted to fit the participant's hand. After instruction, the participant pressed the dynamometer until maximum strength was shown and the results were recorded in kilograms with one decimal. The test was performed 3 times with both hands alternating between hands. Hand dominance was noted. For statistical analysis the maximum of the measurements was chosen [42].

Chair stand test

Participants aged 55 and older were invited to participate in the chair stand test (SC-30). The participant was seated on a chair placed against the wall with the back touching the chair and the feet flat on the ground. The chair was not standardised but at each location a chair with a seat height of 43–45 centimetres without armrests was procured. The arms were crossed at the wrists and the palms were placed loosely around the collarbones. The number of times the participant was able to fully stand up was recorded [43].

Register follow-up

Information on prevalent cardiovascular disease (CVD) from 1977 until date of examination and incident CVD until date of death or register follow-up (31 December 2021) was obtained from health registers. Register data has been obtained to provide follow-up data on diseases for all participants. The Greenland National Patient Register and the Danish National Patient Register provided information on diagnoses and procedures given in the health care system. The Causes of Death Register from both countries provided information on the underlying cause (diagnosis) of death. Lastly, the Central Person Register provided information on emigration, hindering follow-up. The health registers contain International Statistical Classification of Diseases and Related Health Problems- (ICD-) 8, ICD10, and International Classification of Primary Care 2 (ICPC-2) codes, as well as The Classification of Operations and Treatments and The Nordic Medico-Statistical Committee (NOMESCO) Classification of Surgical Procedures for procedures. Information on income will be obtained from Statistics Greenland.

Ancillary studies

Studies on the gut microbiome and on diabetes complications were carried out on the same participants thus piggybacking on the logistics of the population health survey but with separate protocols and separate research ethical processes (see supplementary material).

Feedback to participants and health care providers

Principles of participant feedback were agreed upon with the health care system in Greenland. After examinations, participants were informed about the following results: blood pressure, body mass index, percent body fat, HbA1c, pulmonary function and hand grip strength, and they were given the possibility to discuss their results with a health professional. If, during the examination, we discovered hypertension, chronic obstructive pulmonary disease or diabetes, or in case of severe emotional reactions, the participant was recommended to see a doctor or contact a relevant helpline. In a few cases, the investigators contacted the health care centre directly, e.g. upon unexpected and serious findings, e.g. emotional reactions, foot ulcers or severe retinal abnormalities. Later, the results of the blood tests (glucose, lipids, eGFR), urinary albumin creatinine ratio, diabetes complications and reading of the ECG were sent as a letter to the participants. With permission from the participant, results were also sent to the local health centre.

The main results of the survey were communicated to the Department of Health in April 2019 in a report written in Danish and Greenlandic based on a list of selected indicators for public health corresponding mainly with priorities for Inuuneritta II supplemented by information on blood pressure, lipids and diabetes [44]. Following the publication of the general results, regional reports have been published in Greenlandic and Danish for each of the five municipalities in Greenland.

Conclusion

For 25 years, the population health studies in Greenland have monitored selected chronic diseases and behavioural risk factors for disease and wellbeing. This information is not available from other sources such as for

instance registers. In addition, social determinants of mental health, the influence of childhood conditions on health, and risk factors for diabetes and metabolic diseases have been analysed. The potential of the study is to contribute to the continued monitoring of risk factors and health conditions that are part of Inuuneritta and to study the epidemiology of cardiometabolic diseases and other chronic diseases as well as behavioural risk factors among the Inuit. Some results of the 2018 survey for diet [45–49], diabetes complications [50,51], alcohol [52], muscle strength [53], well-being of older adults [34,54,] and mental health among youth [54,55,] have been published. The population health surveys will be continued and enhanced with support from the Greenland Government. The next population health survey is planned for 2024. The future of the studies of chronic diseases is contingent on external funding.

Acknowledgments

We thank the interviewers, examiners, local citizens who helped make the survey feasible, and the participants who willingly gave their time.

Data availability statement

Until the establishment of facilities for data deposition is available in Greenland, data will be deposited at the Danish National Archives from where it will be made available anonymously upon reasonable request.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Ethics

The main study was approved by the ethical review committee for Greenland (KVUG 2017-05). The study on diabetes complications and on gut microbiome were approved by the same committee (KVUG 2017-11 and KVUG 2017-13). Participants were informed about the study objectives and procedures verbally and in writing and signed a written consent form including consent to pass results on to the local health centre. Participants provided permission to have their samples stored in the biobank to be used for future analyses within the overarching survey themes: cardiometabolic- and lung disease and its risk factors. Approval from local community leadership is not part of the ethical review process in Greenland and was not obtained. Parental consent is not required for participants aged 15 years and older. The study addresses health issues of high priority for public health in Greenland. The challenge in genetic research in indigenous populations is that it raises complex psychological, ethical, social, and political issues. These issues were raised recently in a user survey of genetics in diabetes research [55]. Generally, the communities fully support the research with a specific request to investigate the significance of traditional and modern Inuit lifestyle in order to understand how advising individuals regarding diet and lifestyle can be linked in a culturally appropriate way about health effects and genes.

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References

[1] Bjerregaard P, Larsen CVL. Health aspects of colonization and the post-colonial period in Greenland 1721 to 2014. J Northern Studies. 2016;10:85–106.
[2] Hansen CB, Larsen CVL, Bjerregaard P, et al. The effect of household crowding and composition on health in an Inuit cohort in Greenland. Scand J Public Health. 2020;49(8):921–930.
[3] Bjerregaard P, Dahl-Petersen IK, Larsen CVL. Measuring social inequality in health amongst indigenous peoples in the Arctic. A comparison of different indicators of social disparity among the Inuit in Greenland. SSM Popul Health. 2018;6:149–157.
[4] Bjerregaard P, Curtis T. Cultural change and mental health in Greenland: the association of childhood conditions, language, and urbanization with mental health and suicidal thoughts among the Inuit of Greenland. Soc Sci Med. 2002;54(1):33–48.
[5] Statistics Greenland. 2021. [Cited 2022 June 14]. Available from: https://bank.stat.gl/pxweb/da/Greenland/Greenland__IN__IN99__IN40/INXF1.px/
[6] Bjerregaard P, Jørgensen ME. Prevalence of obesity among Inuit in Greenland and temporal trend by social position. Am J Hum Biol. 2013;25(3):335–340.

[7] Bjerregaard P, Jeppesen C. Inuit dietary patterns in modern Greenland. Int J Circumpolar Health. 2010;69 (1):13–24.
[8] Dahl-Petersen IK, Larsen CVL, Nielsen NO, et al. SIF's Grønlandsskrifter nr. 28. Befolkningsundersøgelsen i Grønland 2014 – levevilkår, livsstil og helbred [Population health survey in Greenland 2014. In Danish]. Copenhagen: National Institute of Public Health, University of Southern Denmark; 2016.
[9] Jørgensen ME, Borch-Johnsen K, Witte DR, et al. Diabetes in Greenland and its relationship with urbanization. Diabetic Med. 2012;29(6):755–760.
[10] Jørgensen ME, Bjeregaard P, Borch-Johnsen K, et al. Diabetes and impaired glucose tolerance among the Inuit population of Greenland. Diabetes Care. 2002;25 (10):1766–1771.
[11] Jørgensen ME, Bjerregaard P, Kjærgaard JJ, et al. High prevalence of markers of coronary heart disease among Greenland Inuit. Atherosclerosis. 2008;196(2):772–778.
[12] Bjørn-Mortensen K, Lynggaard F, Pedersen ML. Incidence of Greenlandic stroke-survivors in Greenland: a 2-year cross-sectional study. Int J Circumpolar Health. 2013;72:22626.
[13] Skotte L, Koch A, Yakimov V, et al. CPT1A missense mutation associated with fatty acid metabolism and reduced height in Greenlanders. Circulation. 2017;10(3). DOI:10.1161/CIRCGENETICS.116.001618
[14] Moltke I, Grarup N, Jørgensen ME, et al. A common Greenlandic TBC1D4 variant confers muscle insulin resistance and type 2 diabetes. Nature. 2014;512(7513):190–193.
[15] Grarup N, Moltke I, Andersen MK, et al. Loss-of-function variants in ADCY3 increase risk of obesity and type 2 diabetes. Nat Genet. 2018;50(2):172–174.
[16] Fumagalli M, Moltke I, Grarup N, et al. Greenlandic Inuit show genetic signatures of diet and climate adaptation. Science. 2015;349(6254):1343–1347.
[17] Bjerregaard P, Dahl-Petersen IK. SIF's Grønlandsskrifter nr. 18. Befolkningsundersøgelsen i Grønland 2005-2007 - Levevilkår, livsstil og helbred [Population health survey in Greenland 2005–2007. In Danish]. Copenhagen: National Institute of Public Health, University of Southern Denmark; 2008.
[18] Pars T, Osler M, Bjerregaard P. Contemporary Use of Traditional and imported food among Greenlandic Inuit. Arctic. 2001;54(1). DOI:10.14430/arctic760
[19] Jeppesen C, Jørgensen ME, Bjerregaard P. Assessment of consumption of marine food in Greenland by a food frequency questionnaire and biomarkers. Int J Circumpolar Health. 2012;71(1):18361.
[20] Ballard T, Coates J, Swindale A, et al., Household hunger scale: indicator definition and measurement guide, Food Nutr Tech, 2011. p. 1–16. https://www.fantaproject.org/sites/default/files/resources/HHS-Indicator-Guide-Aug2011.pdf accessed June 14, 2022; Assistance III Project (FANTA)
[21] Dahl-Petersen IK, Hansen AW, Bjerregaard P, et al. Validity of the international physical activity questionnaire in the Arctic. Med Sci Sports Exercise. 2013;45(4):728–736.
[22] The IPAQ Group. Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) – short and Long Forms 2005. [Cited 2022 June 14]. [Available from: https://docs.google.com/viewer?a=v&pid=sites&src=ZGVmYXVsdGRvbWFpbnx0aGVpcGFxfGd4OjE0NDgxMDk3NDU1YWRlZTM.
[23] Goldberg DP, Gater R, Sartorius N, et al. The validity of two versions of the GHQ in the WHO study of mental illness in general health care. Psychol Med. 1997;27 (1):191–197.
[24] Lynge I, Munk-Jørgensen P, Pedersen AL, et al. Psykisk helbred hos patienter i Grønlands sundhedsvæsen [Mental health among patients admitted to health care facilities in Greenland. In Danish]. Copenhagen: National Institute of Public Health, University of Southern Denmark; 2003.
[25] Toce-Gerstein M, Gerstein DR, Volberg RA. The NODS–CLiP: a Rapid Screen for Adult Pathological and Problem Gambling. J Gambl Stud. 2009;25(4):541–555.
[26] Götestam KG, Johansson A, Wenzel HG, et al. Validation of the Lie/Bet screen for pathological gambling on two normal population data sets. Psychol Rep. 2016;95 (3):1009–1013.
[27] Saunders JB, Aasland OG, Babor TF, et al. Development of the alcohol use disorders identification test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption-II. Addiction. 1993;88 (6):791–804.
[28] Cantril H. The pattern of human concerns. New Brunswick: Rutgers University Press; 1965.
[29] Bendtsen P, Mikkelsen SST. Sundhedsadfærd, helbred og trivsel blandt elever på ungdomsuddannelser [Health behaviour, health and well-being among students in secondary education. In Danish]. Copenhagen:National Institute of Public Health, University of Southern Denmark;2015. J. S. Ungdomsprofilen 2014
[30] Bandura A, Freeman WH, Lightsey R. Self-Efficacy: the exercise of control. J Cognit Psychotherapy. 1999;13(2):158–166.
[31] Stewart-Brown S, Janmohamad K. Warwick-Edinburgh mental well-being scale 2008. [Cited 2022 June 14]. [Available from: https://warwick.ac.uk/fac/sci/med/research/platform/wemwbs/
[32] Kessler RC, Andrews G, Colpe LJ, et al. Short screening scales to monitor population prevalences and trends in non-specific psychological distress. Psychol Med. 2002;32 (6):959–976.
[33] Fletcher C, Riva M, Lyonnais M-C, et al. Definition of an Inuit cultural model and social determinants of health for Nunavik. In: Community Component. Nunavik Inuit Health Survey 2017 Qanuilirpitaa? How are we now? Quebec:Nunavik Regional Board of Health and Social Services (NRBHSS) & Institut national de santé publique du Québec (INSPQ); 2021. p. 1–47.
[34] Nørtoft K, Carroll S, Siren A, et al. Enhancing well-being among older people in Greenland through partnerships of research, practice and civil society. In: Heininen L, Exner-Pirot H, editors. Arctic Yearbook. Akureyri Iceland: Northern Research Forum; 2018. p. 233–252.
[35] Shaikh NA, Downar E. Time course of changes in porcine myocardial phospholipid levels during ischemia. A reassessment of the lysolipid hypothesis. Circ Res. 1981;49(2):316–325.
[36] Lepage G, Roy CC. Direct transesterification of all classes of lipids in a one-step reaction. J Lipid Res. 1986;27(1):114–120.

[37] World Health Organization. Definition, diagnosis and classification of diabetes mellitus and its complications. Report of a WHO Consultation, Part 1: diagnosis and classification of diabetes mellitus. Geneva: World Health Organization, Surveillance DoND; 1999. p. 1–59.
[38] Group KDIGOCW. KDIGO 2012 clinical practice guideline for the evaluation and management of chronic kidney disease. Kidney Int Suppl. 2013;3(1):1–150.
[39] Quanjer PH, Brazzale DJ, Boros PW, et al. Implications of adopting the global lungs initiative 2012 all-age reference equations for spirometry. Eur Respir J. 2013;42(4):1046–1054.
[40] Hall GL, Filipow N, Ruppel G, et al. Official ERS technical standard: global Lung Function Initiative reference values for static lung volumes in individuals of European ancestry. Eur Respir J. 2021;57(3):2000289.
[41] Reddel HK, FitzGerald JM, Bateman ED, et al. GINA 2019: a fundamental change in asthma management. Eur Respir J. 2019;53(6):1901046.
[42] Roberts HC, Denison HJ, Martin HJ, et al. A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. Age Ageing. 2011;40(4):423–429.
[43] Rikli RE, Jones CJ. Senior fitness test manual. Champaign: Human Kinetics; 2001.
[44] Larsen CVL, Hansen CB, Jørgensen ME, et al. SIF's Grønlandstidsskrifter nr. 30. Befolkningsundersøgelsen i Grønland 2018. Levevilkår, livsstil og helbred [Population health survey in Greenland 2018. In Danish]. Copenhagen: National Institute of Public Health, University of Southern Denmark; 2019.
[45] Bjerregaard P, Larsen CVL. Social determinants of dietary patterns, food basket costs and expenditure on alcohol and tobacco amongst Greenland Inuit. Public Health Nutr. 2021;24(15):4975–4984.
[46] Bjerregaard P, Olesen I, Curtis T, et al. Dietary issues in contemporary Greenland: dietary patterns, food insecurity, and the role of traditional food among Greenlandic Inuit in the twenty-first century. In: Hossain K, Nilsson LM, Herrmann TM, editors. Food security in the high north: contemporary challenges across the circumpolar region. Abingdon (UK): Routledge; 2020. p. 92–99.
[47] Bjerregaard P, Olesen I, Larsen CVL. Association of food insecurity with dietary patterns and expenditure on food, alcohol and tobacco amongst indigenous Inuit in Greenland: results from a population health survey. BMC Public Health. 2021;21(1). DOI:10.1186/s12889-021-11123-x
[48] Hansen V, Mosbech A, Rigét FF, et al. Background 210Po activity concentrations in Greenland marine biota and dose assessment. SciTotal Environ. 2022;806:150508.
[49] Senftleber NK, Overvad M, Dahl-Petersen IK, et al. Diet and physical activity in Greenland: genetic interactions and associations with obesity and diabetes. Appl Physiol Nutr Metab. 2021;46(8):849–855.
[50] Christensen MMB, Hansen CS, Fleischer J, et al. Normative data on cardiovascular autonomic function in Greenlandic Inuit. BMJ Open Diabetes Res Care. 2021;9(1):e002121.
[51] Larsen TLJ, Jørgensen ME, Pedersen ML, et al. Low prevalence of retinopathy among Greenland Inuit. Int J Circumpolar Health. 2021;80(1). DOI:10.1080/22423982.2021.1938420
[52] Bjerregaard P, Larsen CVL, Sørensen IK, et al. Alcohol in Greenland 1950-2018: consumption, drinking patterns, and consequences. Int J Circumpolar Health. 2020;79(1). DOI:10.1080/22423982.2020.1814550
[53] Bjerregaard P, Ottendahl CB, Jørgensen ME. Hand grip strength and chair stand test amongst Greenlandic Inuit: reference values and international comparisons. Int J Circumpolar Health. 2021;80(1). DOI:10.1080/22423982.2021.1966186
[54] Ottendahl CB, Bjerregaard P, Svartá DL, et al. Mental sundhed og helbred blandt 15-34-årige i Grønland. Betydningen af opvækstvilkår, beskyttende faktorer og risikofaktorer [Mental health and wellbeing among the 15-34-year-old in Greenland. In Danish]. Copenhagen: National Institute of Public Health, University of Southern Denmark; 2021.
[55] Olesen I, Hansen NL, Jørgensen ME, et al. Perspektiver på genetiske undersøgelser af diabetes, belyst gennem Sharing Circles [Perspectives on genetic studies on diabetes by using Sharing Circles. In: Danish and Greenlandic]. Copenhagen: National Institute of Public Health, University of Southern Denmark; 2020. p. 1–24.