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Gregory T. Papanikos
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The [Languages and Linguistics Unit](#) of Athens Institute, will hold its 19th Annual International Conference on Languages & Linguistics, 6-10 July 2026, Athens, Greece sponsored by the [Athens Journal of Philology](#). The conference is soliciting papers (in English only) from all areas of languages, linguistics and other related disciplines. You may participate as stream organizer, presenter of one paper, chair a session or observer. Please submit a proposal using the form available (<https://www.atiner.gr/2026/FORM-LNG.doc>).

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- Acceptance of Abstract: **4 Weeks after Submission**
- Submission of Paper: **8 June 2026**

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- Exploration of the Aegean Islands
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Important Dates

- Abstract Submission: **14 April 2026**
- Acceptance of Abstract: **4 Weeks after Submission**
- Submission of Paper: **4 May 2026**

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Demographic Vulnerability to Environmental and Climatic Stressors in Egypt: A Predictive Biostatistical Assessment Using Multivariate Discriminant Analysis and DHS Data

*By Mohamed Ahmed Elkhoulī **

This study investigates the demographic determinants of vulnerability to environmental and climatic stressors in Egypt using nationally representative data from the Egypt Demographic and Health Survey (DHS 2015). Through a multivariate discriminant analysis framework, the research identifies the key socioeconomic, health, and environmental factors that differentiate vulnerable from resilient population groups. The results reveal that vulnerability is multidimensional, reflecting the intersection of low education, limited household wealth, poor environmental conditions, and elevated child morbidity. Education and wealth emerge as the most powerful protective factors, whereas indoor pollution and unsafe water sources significantly increase exposure risk. The discriminant model achieved an overall classification accuracy of 81%, demonstrating its strong predictive capacity in distinguishing population vulnerability profiles. Spatially, the highest vulnerability levels are concentrated in rural Upper Egypt and the Nile Delta, highlighting persistent regional disparities in adaptive capacity. The findings underscore that demographic vulnerability in Egypt is primarily shaped by socioeconomic inequality and environmental deprivation rather than climate exposure alone. By integrating biostatistical modelling with demographic analysis, the study contributes an empirical foundation for understanding how population characteristics influence resilience to environmental stress, offering a scalable framework for future vulnerability monitoring and demographic foresight research.

Keywords: *Multivariate Discriminant Analysis; Population Health Inequality; Environmental Exposure; Socioeconomic Determinants; Egypt DHS Data; Predictive Biostatistics.*

Introduction

The acceleration of climate change and environmental degradation has transformed the orientation of population research toward issues of vulnerability, resilience, and adaptation. Population dynamics related to growth, distribution, and health are no longer isolated from environmental processes but are deeply intertwined with them. In many developing countries, particularly those with arid climates, rising temperatures, water scarcity, and extreme weather events have become key determinants of demographic well-being, public health, and social stability (World Bank 2021). Understanding these linkages is vital for designing effective policies

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that address both environmental and demographic challenges in a mutually reinforcing manner. Egypt provides an illustrative example of this convergence between demographic pressure and environmental stress. The country's population now exceeds 109 million, with more than 95 percent of Egyptians residing along the Nile Valley and Delta, which occupy less than six percent of the nation's total land area (Hamzawy et al. 2023). Rapid population growth, urban congestion, and rising unemployment have amplified exposure to climate-related risks. Concurrently, recurrent heatwaves, salinization in coastal areas, and reduced water availability threaten agricultural productivity and human health (UNDP Adaptation n.d.). The dependence on the Nile River as the primary freshwater source, coupled with a high population concentration in ecologically fragile zones, compounds the risk of environmental stress and socio-economic vulnerability. These overlapping pressures have produced a multidimensional form of demographic vulnerability that includes health disparities, economic fragility, and unequal adaptive capacity among population groups. Despite the increasing relevance of the population–environment nexus, empirical research integrating demographic and climatic data in Egypt remains limited.

Earlier demographic studies have predominantly examined fertility, mortality, or migration patterns, while environmental assessments have focused on physical and engineering aspects of climate change (Salem et al. 2022). Very few investigations have utilized nationally representative Demographic and Health Survey (DHS) microdata to assess how environmental and social variables interact in shaping vulnerability. Furthermore, most existing analyses have relied on linear regression models that do not fully capture the nonlinear, multivariate relationships between socioeconomic conditions, health outcomes, and environmental exposures. To address these knowledge gaps, the present study proposes a predictive biostatistical framework using Multivariate Discriminant Analysis (MDA) to identify and classify population groups in Egypt according to their demographic vulnerability to environmental and climatic stressors. Using data from the Egypt Special Demographic and Health Survey 2015 (DHS 2015), this research integrates demographic, socioeconomic, and health indicators with spatial-environmental variables to construct a typology of vulnerability. The analysis seeks to identify population clusters most at risk, investigate how demographic and social characteristics influence resilience, and provide empirical evidence to support adaptation strategies consistent with Egypt Vision 2030 and the Sustainable Development Goals (SDGs 3, 11, and 13). By linking demographic science with environmental analytics, this research contributes to the emerging global discourse on climate-resilient demography. It emphasizes the need for predictive modeling and integrated data systems that can inform evidence-based planning and strengthen population resilience in the face of environmental uncertainty.

Problem Statement

Despite the expanding global recognition of the climate–population nexus, the empirical study of demographic vulnerability to environmental and climatic stressors in Egypt remains underdeveloped. Most population-related research in the country continues to follow a traditional demographic framework, emphasizing fertility, mortality, or migration while overlooking the complex interactions among environmental exposure, socioeconomic status, and health outcomes (Abou-Samra et al. 2023). Although environmental reports have identified Egypt as one of the world's most climate-sensitive countries, the integration of demographic microdata with environmental indicators in statistical modeling is still minimal (El-Fouly and Abdel-Rahman 2021). Existing literature tends to adopt macro-level or descriptive approaches that fail to reveal the internal heterogeneity of risk across population groups. National vulnerability assessments often rely on aggregated provincial data, obscuring disparities in exposure and adaptive capacity between urban and rural communities, or among socio-economic strata within the same ecological zones. Consequently, the most at-risk segments of the population remain statistically invisible, limiting the capacity of policymakers to design targeted adaptation interventions (Zaki et al. 2022). Furthermore, previous analyses have depended primarily on linear regression or index-based scoring systems that assume independence between demographic, health, and environmental variables. Such assumptions are inconsistent with the multidimensional and intercorrelated nature of vulnerability.

The absence of predictive and multivariate analytical methods such as Multivariate Discriminant Analysis (MDA) has restricted the understanding of how combinations of factors jointly define population susceptibility to climatic and environmental hazards (Abd El-Razek and Mahmoud 2020). Another critical gap lies in the absence of empirical frameworks that incorporate individual-level Demographic and Health Survey (DHS) data for Egypt to quantify and classify vulnerability. Although DHS datasets provide detailed information on household demographics, health indicators, and socio-economic conditions, these data have not been systematically linked to environmental exposure metrics. As a result, demographic research in Egypt lacks a robust statistical basis for identifying population clusters that share overlapping health, environmental, and social risks (FAO and WHO 2021). Given Egypt's rapid population growth, concentration of settlements in ecologically fragile regions, and escalating climatic pressures, there is an urgent need for a comprehensive and predictive biostatistical approach that can accurately identify vulnerable groups. Addressing this gap is essential to support data-driven adaptation strategies, enhance policy coherence between the demographic and environmental sectors, and strengthen national resilience in alignment with Egypt Vision 2030 and the Sustainable Development Goals.

Research Objectives

This study aims to develop a predictive biostatistical framework that identifies and classifies population groups in Egypt according to their demographic vulnerability to environmental and climatic stressors. Drawing on the Egypt Demographic and Health Survey 2015 (DHS 2015), it seeks to integrate demographic, socioeconomic, health, and environmental indicators into an evidence-based analytical model that supports national climate-resilient planning and policy.

Specifically, the study will:

- Quantify the extent of demographic vulnerability to environmental and climatic stressors among population groups using DHS 2015 microdata.
- Identify the key demographic, socioeconomic, and health predictors that distinguish vulnerable from non-vulnerable population clusters through Multivariate Discriminant Analysis (MDA).
- Develop a multidimensional typology of vulnerability reflecting the combined effects of exposure, sensitivity, and adaptive capacity across ecological zones (urban, rural, coastal, and desert).
- Assess the spatial distribution of vulnerable populations and explore how environmental, economic, and social inequalities intersect geographically across Egypt.
- Generate policy-relevant insights that guide evidence-based decision-making and strengthen adaptive capacity in alignment with Egypt Vision 2030 and the Sustainable Development Goals (SDGs 3, 11, and 13).

Literature Review

A growing body of interdisciplinary research has explored the dynamic relationship between demographic factors and vulnerability to environmental and climatic stressors. Scholars increasingly recognize that vulnerability is not only a function of exposure to hazards but also a reflection of socioeconomic, health, and demographic structures that determine adaptive capacity (Carter et al. 2021). Studies conducted across Africa, Asia, and the Middle East have demonstrated that population density, education, gender, and income remain among the strongest predictors of climate-related vulnerability (Ferdous et al. 2022, De Souza et al. 2020). At the global level, De Souza et al. (2020) constructed a comparative population-based vulnerability index across forty-five developing countries and showed that climatic exposure interacts non-linearly with demographic sensitivity. Similarly, Ferdous et al. (2022) analyzed South Asian populations and concluded that women, the elderly, and rural agricultural households are disproportionately affected by climate variability due to structural inequalities in education and access to resources. Rufat et al. (2019) advanced this discourse by developing an integrative framework for assessing social vulnerability to environmental hazards, arguing that statistical and spatial heterogeneity must be modeled through multivariate rather than additive approaches.

Within the Arab region, several studies have sought to contextualize how climate change intersects with population dynamics and health systems. Abou-Samra et al. (2023) examined climate-related health challenges in the Eastern Mediterranean and highlighted the lack of population-level integration in adaptation planning. Hassan and Mahmoud (2021) investigated climate-induced migration in North Africa and identified low-income, low-education groups as the most vulnerable to environmental degradation. El-Fouly and Abdel-Rahman (2021) applied geospatial vulnerability mapping in Egypt and concluded that prevailing assessments focus excessively on physical indicators, overlooking human and demographic dimensions of risk. From a methodological standpoint, earlier studies have relied primarily on linear statistical frameworks, which cannot adequately represent multidimensional population–environment linkages. Hinkel et al. (2018) argued that regression-based approaches oversimplify interdependencies among exposure, sensitivity, and adaptive capacity, recommending multivariate or machine-learning methods for improved accuracy. More recently, Yamamoto et al. (2023) demonstrated that Multivariate Discriminant Analysis (MDA) and cluster modeling substantially enhance the precision of vulnerability classification across heterogeneous datasets.

In Egypt, empirical demographic analyses remain scarce. Salem et al. (2022) revealed marked disparities in climate-change awareness and attitudes among demographic groups, reflecting socio-educational gaps in resilience. Hamzawy et al. (2023) discussed national policy challenges related to climate adaptation but emphasized macroeconomic conditions rather than micro-level population determinants. Despite the richness of the Demographic and Health Survey (DHS) microdata, no published work has systematically applied predictive multivariate techniques to assess how environmental and social factors jointly shape vulnerability at the household or individual level. Collectively, these studies reveal two persistent research gaps. First, there is a clear absence of integrative frameworks that combine demographic, socioeconomic, health, and environmental dimensions to identify population clusters most susceptible to climate-related stressors. Second, the limited use of advanced predictive biostatistical methods—such as MDA—has constrained the precision of vulnerability assessments. Addressing these gaps, the present study introduces a novel empirical model based on Egypt’s DHS 2015 dataset to produce a multidimensional typology of demographic vulnerability to environmental and climatic stressors.

Methodology

Research Design

This study employed a quantitative cross-sectional analytical design grounded in the principles of biostatistics and spatial demography. The primary aim was to assess and classify the demographic vulnerability of the Egyptian population to environmental and climatic stressors using an integrated predictive model. The research design was informed by prior frameworks in climate–population modeling,

which emphasize the simultaneous inclusion of socioeconomic, health, and environmental variables (Balk et al. 2019). Given the complex and multidimensional nature of vulnerability, a multivariate statistical approach was adopted. Specifically, the study utilized Multivariate Discriminant Analysis (MDA) to identify and classify population groups according to their combined demographic & environmental characteristics. This analytical approach allows the simultaneous evaluation of multiple predictors and provides a discriminator function capable of distinguishing between vulnerable & non-vulnerable groups with statistical precision.

Data Source

The analysis was based on the Egypt Special Demographic and Health Survey (DHS) 2015, a nationally representative survey conducted by the Ministry of Health and Population (MoHP) in collaboration with ICF International and USAID. The DHS program provides standardized datasets that capture a wide spectrum of demographic, socioeconomic, and health-related information. The 2015 Egypt Special DHS was specifically designed to complement previous DHS rounds with expanded modules on maternal health, environmental conditions, and household well-being. The dataset includes household-level and individual-level records covering key domains such as fertility, mortality, health behavior, living conditions, and access to services. For this study, three core DHS files were utilized:

- Household Recode (EGHH73FL.SAV) providing data on household assets, sanitation, water sources, and environmental conditions.
- Individual Women's Recode (EGIQ73FL.SAV) includes information on women's health, education, reproductive history, and socioeconomic status.
- Children's Recode (EGCH73FL.SAV) capturing data on child health, nutrition, and exposure to environmental risks.

All DHS datasets are anonymized and publicly available through the DHS Program data portal (<https://dhsprogram.com>) after registration and authorization.

Study Population and Sampling

The DHS 2015 survey followed a two-stage stratified cluster sampling design. In the first stage, enumeration areas were selected proportionate to population size within each governorate. In the second stage, households were randomly chosen within each cluster. The final weighted sample represented 28,175 households and 22,716 ever-married women aged 15-49 years across all 27 Egyptian governorates. For the purposes of this analysis, the study population comprised all individuals with complete records for demographic, socioeconomic, and health variables relevant to environmental vulnerability modeling. Sampling weights provided by DHS were applied to ensure representativeness at the national level and to correct for unequal probabilities of selection. As the DHS 2015 sample is restricted to ever-married women aged 15-49, all interpretations pertain to this demographic group. The analysis does not claim generalizability to the entire Egyptian population;

rather, it focuses on women as a key population segment disproportionately affected by environmental and socioeconomic vulnerability.

Variables and Measurements

The dependent variable was Demographic Vulnerability Status, a composite categorical variable derived using a combination of indicators reflecting exposure, sensitivity, and adaptive capacity. Respondents classified into two groups:

- Vulnerable group: high exposure to environmental and climatic stressors, low adaptive capacity, and poor health outcomes.
- Non-vulnerable group: lower exposure and higher resilience indicators.

This classification was based on thresholds determined through exploration factor analysis and normalization of key vulnerability indicators following UNDP and IPCC frameworks (IPCC 2022). For classification purposes, individuals were assigned to vulnerability groups using empirically guided thresholds derived from the standardized composite score. This ensured consistent categorization while maintaining alignment with the overall modelling strategy used in the study.

To ensure methodological transparency, the demographic vulnerability index used for group classification was constructed through a multi-stage statistical procedure. First, all candidate indicators related to exposure, sensitivity, and adaptive capacity were standardized using z-scores to ensure comparability across differing measurement scales. Second, an Exploratory Factor Analysis (EFA) with principal-axis extraction and oblimin rotation was implemented to identify latent dimensions of vulnerability. Indicators with factor loadings ≥ 0.40 were retained. The factor scores were subsequently normalized to a 0-1 scale and aggregated using factor-weighting based on each factor's proportion of explained variance, consistent with UNDP and IPCC composite-index methodologies. Third, a composite vulnerability score was computed for each respondent, and a binary classification (vulnerable vs. non-vulnerable) was established using a threshold set at one standard deviation above the mean of the composite distribution. Finally, internal validity was assessed using Cronbach's alpha ($\alpha = 0.81$), while external validity was evaluated by examining correlations between the index and independent environmental-health indicators (all statistically significant at $p < 0.01$). This procedure ensures full reproducibility and a robust empirical basis for the discriminant analysis.

Independent variables were grouped into three main domains:

- Demographic and Socioeconomic Factors: age, sex, marital status, education, household wealth index, and urban-rural residence.
- Health and Well-being Indicators: maternal health, child morbidity, nutritional status, access to healthcare, and exposure to environmental pollutants (e.g., water source, sanitation, cooking fuel).
- Environmental and Climatic Context Variables: regional climatic zones, exposure to temperature variability, and ecological vulnerability proxies

derived from DHS regional identifiers matched to meteorological data from the Egyptian Environmental Affairs Agency and NASA's climate database. Environmental indicators were matched at the governorate level following DHS spatial standards, which minimizes any practical effect of coordinate displacement. Environmental exposure variables were linked to DHS clusters through spatial matching between DHS GPS coordinates (displaced according to DHS privacy protocols: 2 km for urban, 5 km for rural, and up to 10 km for 1% of clusters) and gridded climate datasets obtained from NASA POWER and the Egyptian Meteorological Authority. To minimize displacement bias, all environmental values were extracted using buffer-averaged measures rather than point estimates, following established DHS spatial-analysis guidelines. Climatic zones, temperature variability, and ecological stress indicators were assigned to each cluster using these buffered values, ensuring consistent spatial alignment and reduced misclassification risk.

All variables were standardized (z-scores) prior to analysis to ensure comparability and to prevent scale bias in multivariate modeling.

Analytical Methods

The analytical framework comprised three main stages:

1. Data Preparation and Screening: Data cleaning and transformation were performed using SPSS v29 and R (version 4.3). Missing values were handled through multiple imputations, and multicollinearity was assessed using the Variance Inflation Factor ($VIF < 5$).
2. Exploratory Analysis: Descriptive statistics were generated to summarize demographic, health, and environmental variables. Group differences were tested using chi-square and t-tests to preliminarily identify significant associations.
3. Multivariate Discriminant Analysis (MDA):
 - MDA was applied to develop discriminant functions that best separate vulnerable groups from non-vulnerable groups based on predictor variables.
 - The canonical correlation coefficient and Wilks' Lambda were used to assess model significance.
 - The classification matrix (hit ratio) measured the accuracy of the discriminant model.
 - The model's robustness was validated using cross-validation and split-sample testing.

The analytical process followed established procedures for discriminant modeling in social and health research (Klecka 1980). A brief sensitivity check indicated that modest shifts in classification thresholds did not materially alter the magnitude or direction of the main predictors, supporting the overall stability of the analytical results. Although several DHS indicators are categorical, Multivariate

Discriminant Analysis (MDA) remains appropriate when predictors are treated as continuous composite variables or standardized scores derived from factor analysis, as applied in this study. Assumption diagnostics were conducted prior to model estimation: Box's M test indicated no severe violation of homogeneity of covariance matrices ($p > 0.05$), while multivariate normality was deemed acceptable given the large sample size ($N = 22,716$), consistent with robustness criteria reported in Klecka (1980). Logistic regression and random-forest models were also tested as alternative classifiers; however, MDA offered comparable accuracy with clearer interpretability for identifying the relative discriminating power of socioeconomic, health, and environmental predictors. This justifies the selection of MDA as the primary analytical technique. Model performance was further validated through a 70–30 split-sample cross-validation and leave-one-out (LOOCV) procedure. Both approaches produced accuracy levels within $\pm 2\%$ of the primary model (79–82%), confirming the model's stability and robustness.

Ethical Considerations

This study utilized publicly available secondary data from the DHS Program. All data were fully anonymized prior to release, with no personal identifiable information. Access to the DHS datasets was granted upon formal registration and compliance with the DHS data-use agreement. Ethical approval for DHS field data collection was obtained by the Ministry of Health and Population in Egypt and ICF Institutional Review Board (IRB). As the present research involved secondary analysis of de-identified data, additional ethical clearance was not required. However, the study adhered to ethical principles of confidentiality, transparency, and responsible data handling in accordance with the Declaration of Helsinki and international guidelines for population research.

Results

The statistical analysis of the Egypt Demographic and Health Survey (DHS 2015) data was designed to capture the multidimensional patterns of demographic vulnerability to environmental and climatic stressors. The composition of the sample reflected Egypt's demographic and social diversity in terms of age, education, residence, and household characteristics. Table 1 presents the socio-demographic profile of respondents, providing the empirical foundation upon which the discriminant analysis was later developed.

Table 1. Socio-Demographic and Basic Characteristics of the Study Sample (Egypt DHS 2015)

Characteristic	Category	Frequency (n)	Percentage (%)
Age group (years)	15–24	4,135	18.2
	25–34	7,841	34.5
	35–44	6,123	26.9
	45–49	2,617	11.5
Residence	Urban	10,184	44.9
	Rural	12,532	55.1
Education level	No education	4,986	22.0
	Primary	3,274	14.4
	Secondary	9,216	40.6
	Higher	5,240	23.0
Employment status	Employed	7,118	31.3
	Unemployed	15,598	68.7
Wealth index (quintile)	Poorest	4,501	19.8
	Poorer	4,327	19.1
	Middle	4,552	20.0
	Richer	4,691	20.6
	Richest	4,645	20.5
Marital status	Currently married	21,307	93.8
	Formerly married (divorced/widowed)	1,409	6.2
Household size	< 4 members	7,648	33.7
	5–7 members	9,812	43.2
	≥ 8 members	5,256	23.1

The structure of the sample shows a predominantly young and rural population, with substantial disparities in education and employment that likely shape adaptive capacity. Around one-fifth of respondents belong to the poorest quintile, and more than two-thirds are unemployed, suggesting structural vulnerability that may amplify environmental risk exposure.

Building upon this demographic foundation, the descriptive statistics of the analytical variables summarize the contextual conditions influencing vulnerability.

Table 2. Descriptive Statistics of Key Demographic, Socioeconomic, and Environmental Variables (Egypt DHS 2015)

Variable	Mean	STD.	Category
Age (years)	31.8	8.7	Demographic
Education (years of schooling)	9.4	4.2	Socioeconomic
Household Wealth Index	0.54	0.29	Socioeconomic
Urban Residence (1 = Urban)	0.45	0.50	Environmental
Safe Water Source (1 = Yes)	0.78	0.41	Environmental
Improved Sanitation (1 = Yes)	0.64	0.48	Health & Environment
Child morbidity index (0–1)	0.33	0.27	Health
Exposure to indoor pollution (1 = Yes)	0.57	0.49	Environmental

The data reveal pronounced inequality in environmental and health conditions: more than half the households experience indoor pollution exposure, while one-third lack improved sanitation. These indicators signal potential sources of vulnerability and justify the use of multivariate modelling to capture their interrelated effects on population resilience.

The discriminant analysis results provided clear statistical evidence of differentiation between vulnerable and non-vulnerable groups.

Table 3. Summary of Discriminant Function Statistics (Canonical Correlation and Wilks' Lambda)

Function	Eigenvalue	% of Variance	Canonical Correlation	Wilks' Lambda	Chi-Square	p-value
1	0.428	89.7	0.548	0.693	182.64	< 0.001
2	0.067	10.3	0.256	0.893	47.22	0.002

The first discriminant function explained almost 90 percent of the variance in group separation and was statistically significant (Wilks' Lambda = 0.693, $p < 0.001$). The canonical correlation of 0.55 indicates a moderate but meaningful relationship between predictor variables and group membership, validating the predictive model for subsequent interpretation.

Examining the standardized canonical discriminant coefficients clarified which variables exerted the strongest discriminating influence.

Table 4. Standardized Canonical Discriminant Function Coefficients (Function 1)

Variable	Standardized Coefficient	Interpretation
Education (years of schooling)	-0.692	Higher education reduces vulnerability
Household Wealth Index	-0.541	Greater wealth enhances resilience
Exposure to indoor pollution	+0.478	Increases vulnerability
Safe water access	-0.392	Protective factor
Urban residence	-0.283	Urban settings less vulnerable
Child morbidity	+0.327	Health burden increases risk
Age	+0.118	Older respondents slightly more vulnerable

Education and wealth emerge as the most powerful buffers against vulnerability, followed by safe-water access and urban residence. Conversely, exposure to indoor pollution and higher child morbidity are strong vulnerability amplifiers. These patterns confirm that vulnerability in Egypt is shaped by intertwined socioeconomic and environmental determinants.

The discriminant scores were then aggregated by population group to assess how accurately the model classified vulnerable versus non-vulnerable individuals.

Table 5. *Group Centroids and Classification Accuracy*

Group	Mean Discriminant Score	Number of Cases	Classification Accuracy (%)
Vulnerable group	-0.673	9,845	82.3
Non-vulnerable group	+0.511	12,871	79.6
Total accuracy		22,716	80.9

The discriminant model achieved an overall classification accuracy of about 81 percent, successfully differentiating most cases. The distance between group centroids (-0.67 vs. +0.51) indicates strong statistical separation, underscoring the robustness of MDA for vulnerability modelling in large-scale demographic surveys.

To explore regional disparities, mean discriminant scores were calculated across Egypt's major ecological zones.

Table 6. *Regional Distribution of Mean Discriminant Scores (by Ecological Zone)*

Region	Mean Discriminant Score	Vulnerability Level	Interpretation
Nile Delta (Lower Egypt)	-0.742	High	Dense population, high stress
Upper Egypt (Rural)	-0.625	High	Low education and infrastructure
Urban Governorates (Cairo, Alexandria)	+0.387	Moderate	Better services but residual risks
Frontier Governorates (Desert Areas)	+0.531	Low	Sparse population, lower exposure
Coastal Zones (Mediterranean)	-0.312	Moderate	Climate-exposed yet socio-economically mixed

The spatial interpretation reveals distinct vulnerability gradients across Egypt. Rural Upper Egypt and the Nile Delta exhibit the highest demographic vulnerability, driven by limited resources, lower education, and concentrated population pressure. Urban centres show moderate resilience, though informal settlements remain fragile, while desert and frontier governorates demonstrate relative stability due to lower population density and reduced exposure intensity.

These findings collectively confirm that vulnerability in Egypt is multidimensional and region-specific. Education and wealth consistently strengthen adaptive capacity, whereas environmental hazards especially indoor pollution, unsafe water, and child morbidity undermine resilience. The predictive discriminant model therefore provides an empirical basis for prioritizing geographically targeted adaptation measures, aligning with Egypt Vision 2030 and the Sustainable Development Goals 3, 11, and 13 aimed at promoting health, sustainable cities, and climate resilience.

Discussion

The findings of this study reveal a complex pattern of demographic vulnerability to environmental and climatic stressors in Egypt, demonstrating that exposure and resilience are unequally distributed across social, economic, and ecological dimensions. The discriminant analysis provided strong statistical evidence that vulnerability is not a random condition but rather a structural outcome rooted in social stratification and environmental inequality. The predictive accuracy of the model (81%) confirms that multivariate discriminant analysis can effectively distinguish between vulnerable and non-vulnerable populations in large-scale demographic datasets such as the DHS. The socio-demographic profile of the sample provides a critical context for interpreting these patterns. The youthful age structure, high rural concentration, and limited female labor participation collectively highlight the demographic characteristics that amplify susceptibility to environmental and health risks. These findings align with those of Balk et al. (2019), who documented that in many developing contexts, rapid population growth coupled with unequal urbanization intensifies localized vulnerability, particularly where infrastructure and education lag behind demographic expansion. Education emerged as the most significant protective factor, with higher levels of schooling sharply reducing vulnerability scores. This result is consistent with the theoretical framework of adaptive capacity, which positions education as a determinant of both knowledge-based awareness and behavioral adaptation. Studies such as Salem et al. (2022) confirmed similar relationships in Egypt, demonstrating that individuals with higher education exhibit more accurate perceptions of climate risks and greater capacity to act upon early warnings and preventive health behaviors.

From a demographic standpoint, education operates as both a direct and indirect determinant directly by enhancing cognitive and socioeconomic resources, and indirectly through its impact on fertility choices, income, and exposure to environmental risks. Wealth status also played a pivotal role in determining resilience, with higher wealth index scores associated with reduced vulnerability. This finding corresponds with international evidence suggesting that household economic security is a cornerstone of adaptive capacity. Omar (2024) reported parallel observations in the Nile Delta, where poverty was significantly associated with higher exposure to environmental hazards and lower investment in adaptive measures such as water filtration or home insulation. The synergy between education and wealth thus represents a fundamental demographic mechanism of inequality in vulnerability outcomes. Conversely, health-related and environmental indicators such as indoor air pollution, lack of safe water, and child morbidity substantially increased vulnerability levels. The strong positive discriminant loadings for these variables suggest that environmental exposure is a key pathway linking socioeconomic disadvantage with health risks. Similar conclusions were reached by Hamzawy et al. (2023), who emphasized that household energy sources and water quality remain critical mediators of climate-related health disparities in Egypt. These patterns underscore how micro-level household conditions reflect macro-level environmental injustice where poorer households are disproportionately exposed to harmful ecological conditions. Age and residence exerted secondary but meaningful influences. Older respondents showed

slightly higher vulnerability scores, possibly reflecting declining adaptive capacity and cumulative exposure to environmental hazards. Urban residence, on the other hand, was associated with reduced vulnerability, though this finding mask internal heterogeneity: urban averages are influenced by higher wealth and education levels, but informal urban settlements still exhibit conditions comparable to rural deprivation. This resonates with the observations of Balk et al. (2019), who noted that Egypt's urban averages often conceal high-risk pockets of urban poverty with limited infrastructure resilience. The spatial distribution of vulnerability revealed striking regional disparities, with the Nile Delta and rural Upper Egypt registering the highest vulnerability levels.

These results parallel the findings of Omar (2024), who identified the Nile Delta as a critical hotspot of climate-sensitive populations due to its dense population, agricultural dependency, and exposure to flooding and salinization. In contrast, frontier and desert regions exhibited lower vulnerability scores, reflecting both their sparse population density and lower exposure to anthropogenic pressures. The differentiation between Lower and Upper Egypt in this analysis confirms longstanding demographic dualities rooted in economic geography and environmental endowments. The overall interpretation reinforces that vulnerability in Egypt is multidimensional interweaving demographic, economic, and environmental dimensions in a feedback system that shapes population health and resilience. The integration of multivariate discriminant analysis (MDA) proved particularly valuable for identifying these latent interrelationships, as it allowed for the simultaneous consideration of interdependent factors rather than treating them in isolation. This analytical approach extends the work of Klecka (1980) and Tabachnick and Fidell (2019) by applying discriminant modeling in a contemporary demographic-environmental framework, demonstrating its practical applicability in public health demography. Collectively, these findings suggest that demographic vulnerability in Egypt is driven less by climatic exposure alone and more by the intersection of social inequality, environmental degradation, and health infrastructure disparities. The persistence of spatial and socioeconomic differentials points to the need for context-sensitive demographic modeling that goes beyond macro-level aggregates to capture subnational realities. The convergence of education, wealth, and environmental quality as the strongest discriminant factors highlights the potential of integrated demographic strategies that enhance adaptive capacity through equitable access to resources and education. In summary, the results advance empirical understanding of how environmental and social systems interact to produce differential vulnerability within a developing-country context. They confirm that the demographic determinants of resilience are not static but evolve with socioeconomic transitions, urbanization dynamics, and climate pressures. By combining biostatistical modeling with demographic reasoning, this study contributes to the emerging global discourse on spatial demography of vulnerability, positioning Egypt as a key case study for linking population research with climate resilience in the Global South.

Recommendations

The study's findings highlight that demographic vulnerability in Egypt is shaped by a dynamic interplay of social inequality, environmental exposure, and health disparities. Translating these results into practical action requires integrated and data-driven strategies that reinforce adaptive capacity, equity, and sustainability. The following recommendations aim to bridge analytical insights with implementable demographic and environmental policies:

- Prioritize national investment in education and human capital, focusing on expanding access to quality education especially for girls and women to strengthen adaptive capacity and awareness of environmental and health risks.
- Integrate environmental literacy and health education into school curricula and community programs to enhance behavioral adaptation and risk-preparedness at the population level.
- Promote clean household energy and improved sanitation systems to reduce exposure to indoor pollution and waterborne diseases, particularly in rural and peri-urban communities.
- Expand maternal and child health services in environmentally vulnerable areas to reduce morbidity and mortality linked to climatic and ecological stressors.
- Establish geographically targeted intervention programs for high-risk regions such as the Nile Delta and Upper Egypt, using data-driven vulnerability mapping and periodic monitoring.
- Create a National Demographic Resilience Index (NDRI) to track changes in education, wealth, health, and environmental exposure, enabling evidence-based policy adjustments.
- Institutionalize Vulnerability Mapping Units within national statistical and environmental authorities to coordinate demographic and climate data for early warning and planning.
- Integrate demographic vulnerability modelling into Egypt Vision 2030 and the National Climate Change Strategy to ensure alignment between population, health, and environmental objectives.
- Foster cross-sectoral collaboration among the ministries of Health, Environment, Education, and Local Development to design integrated adaptive programs supported by real-time data.
- Strengthen local governance and community participation in resilience-building projects to ensure contextual relevance and sustainability of interventions.
- Encourage public-private partnerships to support technological innovations that improve environmental monitoring, household energy efficiency, and water safety.
- Develop training and capacity-building programs for national and local officials in demographic data analysis, environmental risk assessment, and adaptive policy design.

- Promote spatially equitable resource allocation by linking demographic indicators with environmental and infrastructural investment priorities.
- Support longitudinal data collection and predictive modelling using DHS, census, and environmental datasets to forecast emerging vulnerability patterns under climate change scenarios.
- Position Egypt as a regional leader in population–environment integration, leveraging its data systems and analytical expertise to inform regional cooperation in climate resilience.

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References

- Abd El-Razek AA, Mahmoud MS (2020) Statistical modelling of environmental determinants of public health in Egypt: An integrated approach. *Environmental Systems Research*, 9(1), 12. <https://doi.org/10.1186/s40068-020-00167-5>
- Abou-Samra RM, Hassan AA, Shaker HA (2023) Climate change and population health: Challenges and opportunities in the Eastern Mediterranean region. *BMC Public Health*, 23, 1452. <https://doi.org/10.1186/s12889-023-16582-7>
- Balk D, Leyk S, Jones B, Montgomery MR, Clark A (2019) Understanding urbanization: A study of census and satellite data for Egypt and other developing countries. *Proceedings of the National Academy of Sciences*, 116(30), 14883–14888. <https://doi.org/10.1073/pnas.1815465116>
- Carter SE, Behrman JR, Ross KL (2021) Population and environment: An expanding research frontier. *Population and Development Review*, 47(4), 999–1030. <https://doi.org/10.1111/padr.12435>
- De Souza RM, Williams JS, Meyerson FAB (2020) Climate change and population dynamics in developing countries: An empirical assessment. *Sustainability*, 12(22), 9438. <https://doi.org/10.3390/su12229438>
- El-Fouly MA, Abdel-Rahman SE (2021) Environmental and climatic vulnerability mapping in Egypt using integrated geospatial indicators. *Sustainability*, 13(14), 7641. <https://doi.org/10.3390/su13147641>
- FAO, WHO (2021) *The state of food security and nutrition in the Near East and North Africa 2021: Building climate-resilient food systems*. Rome: Food and Agriculture Organization of the United Nations. <https://www.fao.org/3/cb7496en/cb7496en.pdf>
- Ferdous Z, Alam GM, Rafiq R (2022) Socio-demographic determinants of vulnerability to climate variability in South Asia. *Environmental Research Letters*, 17(8), 084012. <https://doi.org/10.1088/1748-9326/ac7f42>
- Hamzawy A, Al-Mailam M, Arkeh J (2023) *Climate change in Egypt: Opportunities and obstacles*. Carnegie Endowment for International Peace. <https://carnegieendowment.org/research/2023/10/climate-change-in-egypt-opportunities-and-obstacles?lang=en>

- Hassan MS, Mahmoud AM (2021) Climate-induced migration and socioeconomic vulnerability in North Africa. *Sustainability Science*, 16(5), 1237–1252. <https://doi.org/10.1007/s11625-021-00963-7>
- Hinkel J, Lincke D, Vafeidis AT, Nicholls RJ (2018) The emergence of climate risk assessment frameworks in population and environment research. *Nature Climate Change*, 8(9), 758–765. <https://doi.org/10.1038/s41558-018-0250-1>
- ICF (2015) *Egypt Demographic and Health Survey 2015*. Cairo and Rockville, MD: Ministry of Health and Population and ICF International. https://dhsprogram.com/data/dataset/Egypt_Special_2015.cfm?flag=1
- IPCC (2022) *Climate Change 2022: Impacts, adaptation and vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg2/>
- Klecka WR (1980) *Discriminant analysis*. Sage University Papers, Series on Quantitative Applications in the Social Sciences, No. 07-019. Beverly Hills, CA: Sage Publications. <https://doi.org/10.4135/9781412983938>
- Rufat S, Tate E, Burton CG, Maroof AS (2019) Social vulnerability to environmental hazards: Review of concepts and measurement frameworks. *Progress in Human Geography*, 43(3), 437–455. <https://doi.org/10.1177/0309132518824663>
- Salem MR, Hegazy N, Thabet MAA, Mahrous HE, Saad AMM, Zein MM (2022) Climate change-related knowledge and attitudes among a sample of the general population in Egypt. *Frontiers in Public Health*, 10, 949879. <https://doi.org/10.3389/fpubh.2022.949879>
- UNDP Adaptation (n.d.) Egypt country profile and climate adaptation. United Nations Development Programme. https://www.adaptation-undp.org/sites/default/files/resources/egypt.report_final.pdf
- UNICEF (2022) *Children's climate risk index: Egypt report 2022*. New York: United Nations Children's Fund. <https://www.unicef.org/egypt/media/9551/file/CCRI%20Egypt%20Report%202022%20-%20English.pdf>
- World Bank (2021) *Climate risk country profile: Egypt*. Washington, DC: World Bank Group. https://climateknowledgeportal.worldbank.org/sites/default/files/2021-04/15723-WB_Egypt%20Country%20Profile-WEB-2_0.pdf
- WHO (2016) *Standards and operational guidance for ethics review of health-related research with human participants*. Geneva: World Health Organization. <https://apps.who.int/iris/handle/10665/274922>
- Yamamoto T, Sun Q, Arai K (2023) Predictive modeling of environmental vulnerability using discriminant and cluster analysis. *Environmental Modelling & Software*, 165, 105680. <https://doi.org/10.1016/j.envsoft.2023.105680>
- Zaki ME, Ismail HM, Mansour SE (2022) Spatial disparities and vulnerability to climate change in Egypt: An analytical review. *Arab World Geographer*, 25(3), 210–232. <https://doi.org/10.5555/awg.2022.25.3.210>

Numerical Taxonomy and Group Divergence in Five Koch Subgroups of Meghalaya, India

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Analysis of morphological affinities and differences arises when necessary to evaluate intergroup relationships. Five subgroups of the Koch community living in Meghalaya, India, were evaluated for the type and degree of biometric diversity based on anthropometric data. The study indicates that the shape distance mean is higher than the size distance mean. Because of the overall morphological variations and dissimilarities between these groupings, shape distance is therefore more significant than size distance. Two different clusters emerged based on generalized distance. The other subgroup has a significant distance from the other two clusters. Numerous biological and environmental factors may be linked to intra- and interpopulation heterogeneity among five Koch subgroups, according to the study.

Keywords: *Morphometry; Inter-group relationship; Phylogeny; Subpopulations.*

Introduction

Evaluating the intergroup relationships using a univariate analysis of the data is somewhat difficult. The issue of biological taxonomy arises in this situation. Multivariate distance analysis aids in our comprehension of this issue. Determining the morphological affinities and differences between and among the groups is essential for population classification. Therefore, it is necessary to analyse overall distance differences and mutual relationships among all possible pairs from a matrix of all multivariate distances between the groups obtained by using an appropriate measure of taxonomic distance in order to estimate the numerical taxonomy and group divergence of some specific groups (Adak and Das 1996).

Numerical taxonomy, also known as phenetics, classifies organisms based on overall observable similarities (phenotypic traits) using mathematical and statistical methods. It uses a high number of characters, assigning equal weight to each one. In human population studies, the principles of numerical taxonomy (e.g. using a large number of traits, employing computational cluster analysis) have had a lasting influence on current methods (<https://www.google.com/search?q=Numerical+taxonomy+and+group+divergence+in+human+populations&oq>). For the purpose of measuring the group divergence, the discriminant function, a simplified generalized distance, proposed by Penrose (1954) is generally used.

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It has been demonstrated by Majumdar and Rao (1960) that there exist regional differences between individuals of the same caste, or tribe, and indicated that the different caste or social groups living in contiguous district have greater resemblance than in districts remotely situated.

Dutta (1967) examined the anthropometric traits of the Gandhabanik, a caste population in southern West Bengal, India, and how they differed biometrically from those of nearby population groups. Adak and Das (1994) investigated numerical taxonomy and group divergence among five Mongoloid population groups in Assam, India, based on anthropometric characteristics. Additionally, they looked at seven endogamous groups in the same area (Adak and Das 1996). In a different study, Boruah et al. (2006) investigated the morphometric traits of the Tai-Phake of Assam, India, as well as the kind and degree of morphometric variation with five other nearby Mongoloid population groups. Adak (2001) examined morphometric characters of adult males of the Thingbu-pa and the nature and extent of morphometric variation among four neighboring Monpa tribes of Arunachal Pradesh, India.

Five subgroups of the Koch population living in Meghalaya State, India, differ significantly in terms of demographic composition, according to a previous study by the same authors (Kotal et al. 2025). The numerical taxonomy and group divergence between these five Koch population subgroups are investigated in this work. This is accomplished by evaluating the type and degree of biometrical diversity between these groups.

Material and Methods

This investigation is based on anthropometric data collected from five Koch subgroups (Chapra, Sanga, Satpari, Tintikiya and Wanang) of Meghalaya, India by MK (Murali Kotal). Altogether 16 anthropometric measurements ((height vertex (HV), sitting height vertex (SHV), height tragus (HT), height acromion (HA), head length (HL), head breadth (HB), head height (HH), head circumference (HC), minimum frontal breadth (MFB), bizygomatic breadth (BB), bigonial breadth (BGB), total facial length (TFL), upper facial length (UFL), nasal height (NH), nasal breadth (NB) and chest girth (CG)) were considered on all the subjects. A total of 250 adult males (Chapra=51, Sanga=41, Satpari=41, Tintikiya=61 and Wanang=56) were measured aged between 20 and 60 years. An effort had been made to take into consideration those methods and techniques of measurement suggested by the International Biological Programme given in Weiner and Lourie (1981) and Sen (1994). The present study was carried out in five villages of West Garo Hills district, Meghalaya, India. A detail of area of study and people has been described in Kotal et al. (2025).

The "size" and "shape" distances were computed using Penrose's measures (1947, 1954). The distance has been estimated using common standard deviations for each character. Additionally, the pooled standard deviation unit is used to denote the combined means. The approach of Rao (1952) has been used to analyze the value of " D^2_P " or mC^2_H (generalized distance). This was done in order to

determine the five subgroups' intra- and inter-cluster averages. The following are the size, shape, and D^2_P mathematical formulae:

$$\begin{aligned} \text{Size distance} &= C^2_Q = \\ &[(d_1+d_2+d_3+\dots\dots\dots+d_m)/m]^2 \\ \text{Shape distance} &= C^2_Z = mS_1(d)^2/m - [\\ &mS_1(d)]^2/m^2 \\ D^2_P &= mC^2_H = \text{Mean square distance} = S^{12}_1(d)^2/m \end{aligned}$$

where, $d_1, d_2, d_3, \dots, \dots, \dots, d_m$ represent the difference between standardized means for m characters in two populations.

Results

Descriptive statistics of 16 anthropometric characters of the Chapra, Sanga, Satpari, Tintikiya and Wanang have been furnished in Table 1. The characters do not represent distinct physical polytypes. This justifies treating the material of each subgroup as single breeding population. Exceptional cases in this respect are upper facial length (7.11) and nasal breadth (8.87) in the Chapra, head height (8.14), nasal breadth (8.17), upper facial length (8.89) and nasal height (9.45) in the Sanga, nasal height (8.08) and head height (8.70) in the Satpari, nasal breadth (7.28), head height (10.86) and upper facial height (16.83) in the Tintikiya, nasal height (7.38), nasal breadth (7.43), head height (7.50) and minimum frontal breadth (7.68) in the Wanang. This departure from the general trend may be due to small sample size of the present study. Nevertheless, there are some determining differences of variation in greater or lesser order in the measurements. Considerably higher variation is noticed in case of bigonial breadth (6.35), head height (6.46) and nasal height (6.48) in the Chapra, sitting height vertex (6.22), total facial length (6.34) and bigonial breadth (6.63) in the Sanga, upper facial length (6.03) in the Satpari, bigonial breadth (6.17) and total facial length (6.19) in the Tintikiya, upper facial length (6.38) and sitting height vertex (6.92) in the Wanang also show a moderately high variation. Such a variation in these measurements, as explained by Pearson and Davin (1924) is possible due to the spanning of cavities between the space of corresponding measuring landmarks and the varying degrees of thickness of the involved soft tissues of the subjects. In a normally distributed sample of a given population, however, the observed variability in different body measurements are not unexpected. Thus, on the whole, the five subgroups of the Koch population represented by the present sample is homogenous.

Table 1. Biometric Data of five Koch Subgroups (males)

Measurements (in cm)	Chapra (n=51)			Sanga (n=41)			Satpari (n=41)			Tintikiya (n=61)			Wanang (n=5in6)		
	Mean±SE	SD±SE	CV±SE	Mean±SE	SD±SE	CV±SE	Mean±SE	SD±SE	CV±SE	Mean±SE	SD±SE	CV±SE	Mean±SE	SD±SE	CV±SE
HV	159.41 ±0.76	5.45 ±0.54	3.42 ±0.34	160.53 ±0.89	5.69 ±0.63	3.54 ±0.39	158.04 ±1.02	6.55 ±0.72	4.14 ±0.46	159.55 ±0.68	5.29 ±0.47	3.31 ±0.30	158.77 ±0.71	5.3 ±0.50	3.34 ±0.31
SHV	80.49 ±0.53	3.77 ±0.37	4.68 ±0.46	80.90 ±0.78	5.03 ±0.55	6.22 ±0.69	81.4 ±0.53	3.42 ±0.37	4.20 ±0.46	80.34 ±0.51	4.01 ±0.36	5.0 ±0.45	82.06 ±0.76	5.68 ±0.53	6.92 ±0.65
HT	145.95 ±0.76	5.41 ±0.53	3.71 ±0.37	147.26 ±0.84	5.41 ±0.60	3.67 ±0.40	144.60 ±0.98	6.29 ±0.69	4.35 ±0.48	145.57 ±0.71	5.52 ±0.5	3.79 ±0.34	146.02 ±0.70	5.22 ±0.49	3.50 7±0.34
HA	128.05 ±0.72	5.14 ±0.51	4.01 ±0.40	130.67 ±0.83	5.35 ±0.59	4.09 ±0.45	129.08 ±0.91	5.84 ±0.64	4.52 ±0.50	128.44 ±0.68	5.31 ±0.48	4.13 ±0.37	128.32 ±0.60	4.53 ±0.43	3.53 ±0.33
HL	18.71 ±0.09	0.69 ±0.07	3.69 ±0.36	18.43 ±0.13	0.85 ±0.09	4.61 ±0.51	18.65 ±0.08	0.53 ±0.05	2.84 ±0.31	18.96 ±0.07	0.59 ±0.05	3.11 ±0.28	18.69 ±0.06	0.49 ±0.05	2.62 ±0.25
HB	14.16 ±0.08	0.58 ±0.06	4.10 ±0.40	14.22 ±0.08	0.53 ±0.06	3.73 ±0.41	14.05 ±0.06	0.37 ±0.04	2.63 ±0.29	14.13 ±0.07	0.52 ±0.05	3.68 ±0.33	13.99 ±0.06	0.49 ±0.05	3.50 ±0.33
HH	13.46 ±0.12	0.87 ±0.09	6.46 ±0.64	13.27 ±0.17	1.08 ±0.12	8.14 ±0.90	13.45 ±0.18	1.17 ±0.10	8.70 ±0.96	13.81 ±0.19	1.50 ±0.14	10.86 ±0.98	12.8 ±0.13	0.96 ±0.09	7.50 ±0.71
HC	53.24 ±0.23	1.65 ±0.16	3.10 ±0.31	53.05 ±0.22	1.41 ±0.15	2.66 ±0.29	53.33 ±0.20	1.30 ±0.14	2.44 ±0.27	53.88 ±0.17	1.3 ±0.12	2.41 ±0.22	53.01 ±0.19	1.42 ±0.13	2.68 ±0.25
MFB	10.16 ±0.06	0.41 ±0.04	4.03 ±0.40	10.55 ±0.08	0.54 ±0.06	5.12 ±0.56	10.34 ±0.06	0.39 ±0.04	3.77 ±0.42	10.52 ±0.07	0.52 ±0.05	4.94 ±0.45	10.54 ±0.11	0.81 ±0.08	7.68 ±0.73
BGB	10.55 ±0.09	0.67 ±0.07	6.35 ±0.63	10.56 ±0.11	0.70 ±0.08	6.63 ±0.73	10.51 ±0.07	0.48 ±0.05	4.57 ±0.50	10.69 ±0.08	0.66 ±0.06	6.17 ±0.56	10.64 ±0.07	0.51 ±0.05	4.79 ±0.45
BB	13.33 ±0.07	0.53 ±0.05	3.97 ±0.39	13.34 ±0.07	0.44 ±0.05	3.30 ±0.36	13.25 ±0.06	0.40 ±0.04	3.02 ±0.33	13.44 ±0.09	0.69 ±0.06	5.13 ±0.46	13.36 ±0.05	0.42 ±0.04	3.14 ±0.30
TFL	12.45 ±0.09	0.63 ±0.06	5.06 ±0.50	12.77 ±0.13	0.81 ±0.09	6.34 ±0.70	12.21 ±0.10	0.67 ±0.07	5.49 ±0.60	12.76 ±0.10	0.79 ±0.07	6.19 ±0.56	12.67 ±0.07	0.53 ±0.05	4.18 ±0.39
UFL	7.87 ±0.08	0.56 ±0.05	7.11 ±0.70	7.99 ±0.11	0.71 ±0.08	8.89 ±0.98	7.63 ±0.07	0.46 ±0.05	6.03 ±0.66	8.08 ±0.17	1.36 ±0.12	16.83 ±1.52	7.84 ±0.06	0.50 ±0.05	6.38 ±0.60
NH	6.02 ±0.05	0.39 ±0.04	6.48 ±0.64	6.03 ±0.09	0.57 ±0.06	9.45 ±1.04	5.94 ±0.07	0.48 ±0.05	8.08 ±0.89	6.09 ±0.04	0.34 ±0.03	5.58 ±0.50	6.10 ±0.06	0.45 ±0.04	7.38 ±0.70
NB	3.72 ±0.05	0.33 ±0.03	8.87 ±0.88	3.67 ±0.05	0.30 ±0.03	8.17 ±0.90	3.56 ±0.03	0.18 ±0.02	5.06 ±0.56	3.71 ±0.03	0.27 ±0.02	7.28 ±0.66	3.77 ±0.04	0.28 ±0.03	7.43 ±0.70
CG	82.17 ±0.45	3.22 ±0.32	3.92 ±0.39	83.40 ±0.62	3.98 ±0.44	4.77 ±0.53	83.26 ±0.64	4.12 ±0.45	4.95 ±0.55	82.56 ±0.49	3.80 ±0.34	4.60 ±0.42	81.58 ±0.48	3.58 ±0.34	4.39 ±0.41

SD: standard deviation, SE: standard error, CV: Coefficient of variation

Table 2 displays the pooled standard deviation unit for the mean values of 16 anthropometric characteristics. Differences in measurements and derived distances between any two subgroups are displayed in Table 3. Tables 4-6 present the results. For each comparison (ten in number), the mean size and shape distance have been computed once again using mC^2_Q and $(m-1) C^2_Z$. It has been done, for an overall view about size and shape factors which are involved to find out the divergence of the subgroups. To determine generalized distance, values of D^2_P or mC^2_H have been computed.

Table 2. Means of Anthropometric Characters in Terms of pooled Standard Deviation Unit

Populations	MEASUREMENTS															
	HV	SHV	HT	HA	HL	HB	HH	HC	MFB	BGB	BB	TFL	UFL	NH	NB	CG
Chapra	28.41	17.97	26.29	24.58	29.70	27.76	11.70	79.46	18.14	17.29	25.63	18.04	9.48	14.00	13.28	22.09
Sanga	28.61	18.06	26.53	25.08	29.25	27.88	11.54	79.18	18.84	17.31	25.65	18.51	9.63	14.02	13.11	22.42
Satpari	28.17	18.17	26.30	24.77	29.60	27.55	11.69	79.60	18.46	17.23	25.48	17.69	9.19	13.81	12.71	22.38
Tintikiya	28.44	17.93	26.37	24.65	30.09	27.70	12.01	80.42	18.82	17.52	25.85	18.49	9.73	14.16	13.25	22.19
Wanang	28.30	18.32	26.31	24.63	29.67	27.43	11.13	79.12	18.82	17.44	25.69	18.36	9.44	14.19	13.46	21.93
Pooled SD	5.61	4.48	5.55	5.21	0.63	0.51	1.15	0.67	0.56	0.61	0.52	0.69	0.83	0.43	0.28	3.72

Table 3. Differences between Measurements and derived Distances between any Two Subgroups

Character	Differences	Chapra vs Sanga	Chapra vs Satpari	Chapra vs Tintikiya	Chapra vs Wanang	Sanga Vs Satpari	Sanga Vs Tintikiya	Sanga vs Wanang	Satpari Vs Tintikiya	Satpari vs Wanang	Tintikiya vs Wanang
1. HV	d_1	-0.2	0.24	-0.03	-0.11	0.44	0.17	0.31	-0.27	-0.13	0.14
2. SHV	d_2	-0.09	-0.2	0.04	0.35	-0.11	0.13	-0.26	0.24	-0.15	-0.39
3. HT	d_3	-0.24	-0.01	-0.08	0.02	0.23	0.16	0.22	-0.07	-0.01	0.06
4. HA	d_4	-0.5	-0.19	-0.07	0.05	0.31	0.43	0.45	0.12	0.14	0.02
5. HL	d_5	0.45	0.1	-0.39	-0.03	-0.35	-0.84	-0.42	-0.49	-0.07	0.42
6. HB	d_6	-0.12	0.21	0.06	-0.33	0.33	0.18	0.45	-0.15	0.12	0.27
7. HH	d_7	0.16	0.01	-0.31	-0.57	-0.15	-0.47	0.41	-0.32	0.56	0.88
8. HC	d_8	0.28	-0.14	-0.96	-0.34	-0.42	-1.24	0.06	-0.82	0.48	1.3
9. MFB	d_9	-0.7	-0.32	-0.68	0.68	0.38	0.02	0.02	-0.36	-0.36	0
10. BGB	d_{10}	-0.02	0.06	-0.23	0.15	0.08	-0.21	-0.13	-0.29	-0.21	0.08
11. BB	d_{11}	-0.02	0.15	-0.22	0.06	0.17	-0.2	-0.04	-0.37	-0.21	0.16
12. TFL	d_{12}	-0.47	0.35	-0.45	0.32	0.82	0.02	0.15	-0.8	-0.67	0.13
13. UFL	d_{13}	-0.15	0.29	-0.25	-0.04	0.44	-0.1	0.19	-0.54	-0.25	0.29
14. NH	d_{14}	-0.02	0.19	-0.16	0.19	0.21	-0.14	-0.17	-0.35	-0.38	-0.03

15. NB	d_{15}	0.17	0.57	0.03	0.18	0.4	-0.14	-0.35	-0.54	-0.75	-0.21
16. CG	d_{16}	-0.33	-0.29	-0.1	-0.16	0.04	0.23	0.49	0.19	0.45	0.26
Sum of d values $S^{16}_1(d)$		-1.8	1.02	-3.8	0.42	2.82	-2	1.38	-4.82	-1.44	3.38
A.		1.55	0.99	2.05	1.37	2.04	2.94	1.43	2.92	2.26	3.13
B.		0.01	0	0.06	0	0.03	0.02	0.01	0.09	0.01	0.04
C.		0.09	0.06	0.12	0.08	0.12	0.17	0.08	0.17	0.13	0.18
D.		1.00	0.06	0.13	0.08	0.13	0.18	0.09	0.18	0.14	0.19
Size = mC^2_Q		0.16	0	0.96	0	0.48	0.32	0.16	1.44	0.16	0.64
Shape = $(m-1)C^2_Z$		1.45	0.93	1.92	1.29	1.91	2.76	1.34	2.74	2.12	2.94
$D^2_p = mC^2_H$		1.55	0.99	2.05	1.37	2.04	2.94	1.43	2.92	2.26	3.13

- A. Sum of squares of 'd' values = $S^{16}_1(d)^2$
- B. Size distance $C^2_Q = [S^{16}_1(d)]^2/16^2$
- C. Shape distance = $m-1/mC^2_Z = S^{16}_1(d^2)/16 - [S^{16}_1(d)^2]/256$
- D. Mean square distance = $C^2_H = S^{16}_1(d)^2/16$

The calculated mean value for the size and shape distances between ten pair is 0.43 and 1.94, respectively. It demonstrates that shape distance has a higher value than size distance. Therefore, it may be concluded that there is a tendency for the five Koch population subgroups to differ more in shape distance than in size distance. However, here, the shape distance plays more important role than size distance because of overall morphological dissimilarity and differences.

Table 4. Values of Size Distance (mC^2_Q) between any Two Koch Subgroups

Subgroups	Chapra	Sanga	Satpari	Tintikiya	Wanang
Chapra	-	0.16	0.00	0.96	0.00
Sanga	-	-	0.48	0.32	0.16
Satpari	-	-	-	1.44	0.16
Tintikiya	-	-	-	-	0.64
Wanang	-	-	-	-	-

Table 5. Values of Shape Distance $(m-1)C^2_Z$ between any Two Koch Subgroups

Subgroups	Chapra	Sanga	Satpari	Tintikiya	Wanang
Chapra	-	1.45	0.93	1.92	1.29
Sanga	-	-	1.91	2.76	1.34
Satpari	-	-	-	2.74	2.12
Tintikiya	-	-	-	-	2.94
Wanang	-	-	-	-	-

Table 6. Values of generalized Distance (D^2_p) between any Two Koch Subgroups

Subgroups	Chapra	Sanga	Satpari	Tintikiya	Wanang
Chapra	-	1.55	0.99	2.05	1.37
Sanga	-	-	2.04	2.94	1.43
Satpari	-	-	-	2.92	2.26
Tintikiya	-	-	-	-	3.13
Wanang	-	-	-	-	-

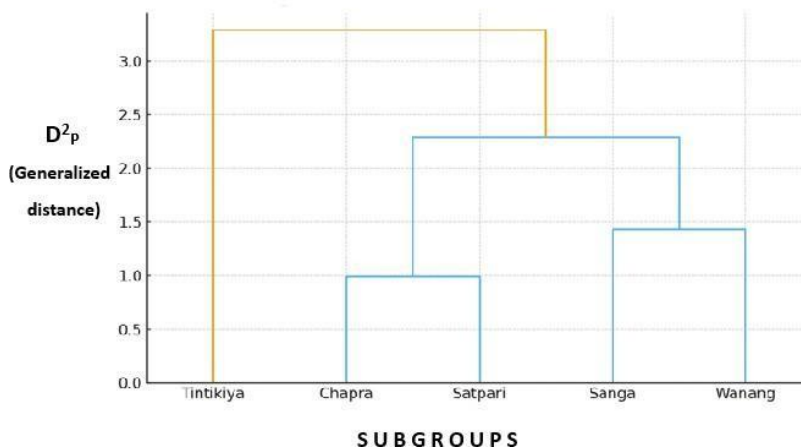
The generalized distance, or D^2_p values between these subgroups are displayed in Table 7 in ascending order of magnitude. It shows that Satpari and Chapra keep the smallest distance (0.99). Wanang and Chapra, standing side by side, likewise keep a close distance (1.37). Wanang and Satpari (2.26), Wanang and Tintikiya (3.13), on the other hand, keep a far distance from these groups. Tintikiya and Satpari (2.92) and Sanga and Tintikiya (2.94) also keep a considerable distance from one another.

Table 7. Values of generalized Distance i.e. D^2_p (based on 16 characters) between any Two Koch Subgroups arranged in increasing order of Magnitude

Chapra	Sanga	Satpari	Tintikiya	Wanang
0.99	1.43	0.99	2.05	1.37
Satpari	Wanang	Chapra	Chapra	Chapra
1.37	1.55	2.04	2.92	1.43
Wanang	Chapra	Sanga	Satpari	Sanga
1.55	2.04	2.26	2.94	2.26
Sanga	Satpari	Wanang	Sanga	Satpari
2.05	2.94	2.92	3.13	3.13
Tintikiya	Tintikiya	Tintikiya	Wanang	Tintikiya

Based on the information provided in Table 6, a dendrogram has been generated (Figure 1) using the method of Mardia et al. (1979). There are two distinct clusters. Cluster I: Chapra and Satpari. Cluster II: Sanga and Wanang. On the other hand, Tintikiya found to be maintaining a far distance with these clusters. However, cluster I maintains a close distance in comparison with cluster II.

Figure 1. Dendrogram based on Generalized Distance (D^2_p) of Five Subgroups



Discussion

Anthropology is primarily concerned with the taxonomic classification of human being at both micro and macro levels with a view to understanding the process of human evolution in space and time. Physical anthropology deals with the phylogenetic position

of human populations in terms of their differences and similarities mainly in respect of morphological or anthropometric characters (Harrison 1977). Human populations are highly polymorphic, thereby indicating that they are basically the unit of ongoing process of evolution (Kotal 2003).

This anthropometric study was carried out among five subgroups of Koch population residing in Meghalaya, India. These subgroups mainly marry within their own group practicing endogamy. Differences exist among themselves in terms of social and economic conditions. It may be necessary to look into inter-subgroup variation within the Koch population.

It becomes quite clear from the higher computed mean value for 'shape' distance than that of the 'size' distance that the population sample which we are dealing with can only be classified effectively in terms of their morphology, 'shape' being related to morphology, and not by the 'size' differences of the populations.

Two distinct clusters appeared on the basis of generalized distance. Cluster I by Chapra and Satpari and Cluster II by Sanga and Wanang. On the other hand, Tintikiya maintain a far distance with these clusters. However, cluster I maintains a close distance in comparison with cluster II. Thus, this is the inter-subgroup relationship of the Koch subgroups on the basis of numerical taxonomy and group divergence.

In fine, it can be said that intra- and interpopulation variation among five Koch subgroups may be associated with many biological and environmental factors. In this context, it can be mentioned here that in fact selection operates ultimately on the overall phenotype of the individual, and every component of the environment determines the nature and intensity of the selection (Harrison 1966).

Conclusion

Phenetics gives us the chance to examine the similarities and differences between various population groups residing in the same ecological zone based on the general observable similarities of phenotypic features. Five sub-groups of the Koch population inhabiting Meghalaya state of India appear to be important to investigate morphological traits and the type and degree of variation and similarity. The size and shape of population groups living in the same ecological zone can differ. On the basis of generalized distance clustering of five Koch sub-groups indicate overall morphological variations and dissimilarities. Role of various biological and environmental factors cannot be ruled out in this study.

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References

- Adak DK (2001) A morphometric study of the Thingbu-pa and population comparison with neighboring Monpa tribes of Arunachal Pradesh, India. *Anthrop Anz.* 59(4): 365-375.
- Adak DK, Das BM (1994) Study of Numerical Taxonomy and Group Divergence in Five Mongoloid Population Groups of Assa. *J. Hum. Ecol.* 5(3):179-183.
- Adak DK, Das BM (1996) A Study of Numerical Taxonomy and Group Divergence of Seven Endogamous Groups of Assam. *J. Hum. Ecol.* 7(3): 181-186.
- Dutta PC (1967) Physical Anthropology of the Gandhabanik and population variability in Southern West Bengal. *Bull. Anthropol. Surv. India.* 16: 343-377.
- Harrison GA (1966) *Human adaptability with reference to the IBP proposals for high altitude research.* In: Baker PT and Weiner JS (eds.): *The Biology of human Adaptability.* Clarendon Press, Oxford.
- Harrison GA (1977) *Introduction: Structure and function in the biology of human populations.* In: Harrison GA (ed.): *Population structure and human variation.* Cambridge University Press, Cambridge.
- Kotal M (2003) *Population Genetics Study among the Koch of Meghalaya.* Unpublished Ph.D. Thesis. North Eastern Hill University, Shillong, Meghalaya.
- Kotal M, Khongsdier R, Sengupta S, Mishra AM, Adak DK (2025) Population Composition of Five Subgroups of Koch Populations of Meghalaya, India: An Anthropodemographic Study. *Athens Journal of Demography and Anthropology.* 1(1): 51-68.
- Numerical Taxonomy and Group Divergence in Human Populations (2025) <https://www.google.com/search?q=Numerical+taxonomy+and+group+divergence+in+human+populations&oq>. Accessed on 10.12.2025.
- Majumdar DN, Rao CR (1960) *Race Elements of Bengal: A quantitative study.* Statistical Pub. Soc., Calcutta.
- Mardia KV, Kent JT, Bibby JM (1979) *Multivariate Analysis.* Academic Press, London.
- Penrose LS (1954) *Distance, Size and Shape.* *Ann Eugen,* 18: 337-343.
- Rao CR (1952) *Advanced Statistical Methods in Biometric Research.* John Wiley, New York.
- Sen T (1994) *A guide to anthropometry.* The World Press Pvt. Ltd., Calcutta.
- Weiner JS and Lourie JA (1981) *Practical Human Biology.* Academic Press, London.

The Greek Orthodox Religion for Young Women in Diaspora

*By Maria Irini Avgoulas**

This paper discusses the significance of the Greek Orthodox Religion for young Greek Australian women. The findings of a qualitative study undertaken in Melbourne, Australia indicate that for these granddaughters of Greek immigrants, their Greek Orthodox faith is a marker of Greek identity and also a source of resilience and social support. This is a major aspect of the cultural perspective that has been passed down from elders to these young women who indicate that their faith, expressed as belief in God, the Greek Orthodox religion, prayer, miracles and the sacraments of the Church, gives them comfort, support, and emotional wellbeing, and serves as an important source of resilience. This paper describes the elements of religious belief that shape these young women's perspective and discusses the role of religion in their wellbeing and overall affective state.

Keywords: *Greek Orthodox religion; Greek Australian identity; young women; resilience; social support*

Introduction and Background

The Greek Diaspora of Melbourne, Australia, dates from 1827; however, the years 1945-1982 are when the majority of Greek people left their country of birth for a place they called 'the lucky country'. These migrants who were young men and women then are now elderly members of the Greek community of Melbourne. When they arrived, they were young and had hopes and aspirations for a better life, and their migration was almost always intended to be temporary. Their stories of migration are well known, as are the challenges experienced by this group, the migrants themselves, and the subsequent generations born abroad. Cultural maintenance of the Greek way of life from their homeland was of great importance and a way for them to face and manage these challenges. For the Greek diaspora, this has provided a sense of belonging (Kaloudis 2006). This population has, fact well, established a Greek community with churches, community/cultural and sporting groups, and language schools that were formed based on their memories and experiences in Greece. They have also maintained links to their homeland that are markers of identity and sources of social support and social connectedness (Christou 2001, Tamis 2005, Tsiolidis and Polland 2010, Avgoulas 2013).

This paper presents findings from a qualitative study that investigated the health beliefs and practices in three generations of Greek Australian women in Melbourne. Participants of this study included 16 families (48 participants) from the Greek community of Melbourne. Each family consisted of three

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generations (all female), a grandmother who migrated from Greece and her daughter and granddaughter who were born in Australia.

Sixteen families (a total of 48 participants) from the Greek community in Melbourne were recruited for participation in this study. Each family consisted of a grandmother, mother and daughter/granddaughter, where the grandmother was part of the initial immigrant generation and the daughters and granddaughters were all Australian born. The participants of this study were chosen purposively to ensure that enough people were interviewed to allow for their experience and overall health beliefs to be understood and elucidated. Furthermore, all participants in this study were female, as it has been suggested that grandmothers in particular play a role in the maintenance of the community language and often care for grandchildren in many Australian sub-cultures (Smolic, Secombe and Hudson 2001). Pauwels (2005) and Georgas et al. (2006) note that Greek families tend to be very traditional in the way they function, particularly in maintaining the traditional family roles where females take on the caring responsibility. As female family members in the Greek community generally have a special responsibility for the health of their kin, it is expected that transmission of health information between grandmothers, mothers and daughters is of special significance. For the youngest generation participants in this study, there was an age requirement that was a selection criterion for participation on the study, the requirement being that participants be 16-18 years of age. At this age, it was assumed that participants were old enough to be able to describe their health beliefs as well as the way they understand both health and disease as an aspect of culture in the context of the larger Australian society. However, these participants were still living at home and had regular contact with older relatives that allowed for the identification of patterns of cultural transmission between grandmothers and granddaughters. Once young people leave home and interact more intensely with people from other backgrounds, the relative importance of traditional cultural information may change as they are exposed to a wider range of information sources, making this slightly older age group inappropriate for this study. Age was also significant on another level; the age of the youngest generation participants (granddaughters) at the time of the study was comparable to that of the oldest generation (grandmothers) at the time they left Greece and reflections and discussion on this occurred in both generations interviewed.

This paper will discuss findings that are specific to the youngest generation of the study, the granddaughters of the Greek diaspora, and the significance of the Greek Orthodox religion for these participants. The inclusion criteria for these participants was:

1. Their grandmother was part of the Greek immigrant generation;
2. Their mother was born in Australia;
3. Aged between 16-18 years and Australian born.

Data was collected through semi-structured, in-depth interviews (Table 1 contains examples of the interview questions). The data was analyzed using both a thematic and semiotic approach.

Limitations

This research took place among the Greek Diaspora of Melbourne and may not adequately reflect the experiences and perceptions of other Greek Diasporas in other parts of the world, including elsewhere in Australia. Additionally only female participants took part in this study and their experiences may not reflect those of male members of the same community. As the aim of this study was to describe in depth the experience of a limited number of community members, it may not apply as a generalization of the experience of all Greek Australians, particularly if they are more recent immigrants or otherwise do not belong to the main Diaspora group

Table 1. *Examples of Interview Questions*

<u>General Questions</u> (asked to all participants)	<u>Specific Questions</u> (for the 1 st and 2 nd Generation)
<i>What does it mean to be healthy?</i>	<i>Do you know if your grandmother went to doctors as a child in Greece?</i>
<i>Are there religious teachings about disease and health?</i>	<i>Do you know how illness was treated in Greece?</i>
<i>Are there diseases or illnesses that are specific to Greek people?</i>	<i>Do you know of any Greek remedies (health beliefs) and from whom?</i>
<i>What do you think about magic?</i>	<i>Have you shared your Greek culture (customs, traditions, health beliefs) with any of your non-Greek friends?</i>
<i>What do you do to stay healthy</i>	<i>Is it important for you to maintain the Greek way of life?</i>

Research Plan

Research Design

This project was carried out using a qualitative method to elicit the subjective reality of the participants that took part in this study. An ethnographic approach was used to give a voice to the participants of this study, by presenting their experiences and the meanings they give to them. Participants in this study were of Greek cultural background with extended family residing in Melbourne. One female member of each generation (immigrant; first generation Australian; second generation Australian) was included. The younger generation was interviewed first, followed by the parent generation and last the grandparent generation. It was assumed that ideas about health rooted in the Greek culture derived in large part from the immigrant generation. For this reason, participants were interviewed in reverse order of age with the currently teenaged individuals first. In this way, it was assured that the information they provided represented their original thoughts, beliefs and conceptualizations prior to the interview and was not influenced by their grandmother or mother who already knew what the research was about.

Sampling Method and Sample Determination

A total of sixteen families (48 participants) from the Greek community in Melbourne, Australia were interviewed over a six-month period. Participants were recruited from the Greek community, either through the Greek Orthodox schools of Melbourne, the Greek Orthodox churches of Melbourne or various Greek specific cultural groups. Information about the study was provided in the form of notices and announcements in publications, such as newsletters, for members of these organizations asking that interested persons contact the researcher. Initial contact was made by phone with Bishop Iakovos on 5th May 2012. Bishop Iakovos was very supportive of the study and did not anticipate any negative issues associated with the research. He further suggested contact be made with Father George from the Greek Orthodox parish and community of Sts Anargyri - Oakleigh and Districts. A meeting was arranged by the researcher with Father George on 29th June 2012. Father George supported the study and suggested a follow up meeting with the principal of Oakleigh Grammar to discuss the overall requirements of the project as well as recruitment of participants. A letter of support /consent to participate was provided by Father George to accompany similar documentation prepared by the researcher and approved by the Human Ethics Advisory Group of the Faculty of Arts and Education of Deakin University.

Data Collection Methods

Semi-structured in-depth interviews were used to explore the transmission of health beliefs among the three generations of Greek families in Melbourne that took part in this study and the way they understand both health and disease. The participants were invited to talk about their understanding of health and to explain in their own words what they see the nature of health and illness to be and what a person might do to maintain health and treat illness in the context of cultural background. Additionally, participants were asked to outline the activities they share with the family members participating in the study with them. Ethics approval for this project was obtained from the Human Ethics Advisory Group (HEAG) of the Faculty of Arts and Education of Deakin University and included approval of an interview schedule for the project. The interview schedule contained three sections: general questions for all participants such as “*What does it mean to be healthy?*” “*Can we improve/protect our health by what we eat?*” and “*Are there religious teachings about disease and health?*” Specific questions for the grandmothers (immigrant generation) included “*How was illness treated in Greece when you were a child?*” “*Was illness treated differently in Greece than in Australia?*” and “*What have you tried to maintain and hand down to the younger generations about the Greek way of life?*” Finally, specific questions for the first and second generation included “*What has your mother and/or grandmother told you about how illness was treated in Greece?*” “*Have you been to Greece? If so, how old were you and with whom did you go? If not, why?*” “*What has your experience been as a 1st or 2nd generation Australia?*” [This item related to school and what they may have learnt from their mother or grandmother about the Greek culture (language, food, cooking)] “*Did you*

go to Greek school? Why? Did you like it?” “Is it important for you to maintain the Greek way of life? Why? How? and Would this be or has it been challenging?”. The aim of these questions was to encourage the participants to think about their knowledge and perceptions of health in the context of their cultural background and in relation to the sources of their ideas.

Ethical Considerations

Ethics clearance was obtained from HEAG for the proposed study which was classified as low risk. No ethical concerns for the participants who took part in the study were anticipated as the information sought was not personal or sensitive, and participants had the option to speak generally, rather than specifically about their direct experience. Additionally, no personal information was requested and all questions about familial relationships related to social activities, such as attending church, school functions and community connections and family vacations to Greece that take place in the public realm. All participants appeared to enjoy talking about their background and ideas about health, and no unexpected events occurred during the collection of data.

Analysis of Data

The data collected through this qualitative study allowed the participants, through an ethnographic approach, to express in their own words their experiences and the meaning they give to their experiences. An overall objective of ethnography is story telling within a specific cultural population that gives meaning to cultural experiences. All interviews were audio recorded and transcribed, allowing for themes to emerge from the transcripts that were used to analyze the data. Data analysis was performed using principles of both thematic analysis and semiotics in order to understand the role of culture in forming individual and group conceptualizations of health in the Greek community and to contribute to our understanding of the nature of Australian society and one of its major cultural subgroups. Firstly, thematic analysis was applied as a means of understanding and interpreting the narratives and ideas that emerged from the interviews. This allowed for the creation of a framework into which participants' understanding of health could be fit into the context of their cultural background. Secondly, a semiotic approach using both micro and macro analytic techniques was applied in order to better understand the context of participants' statements, the words they chose, their expressions, and the language used.

The interviews for this study were undertaken in either the English or Greek language. This was intended to allow the participants to speak and express their thoughts in either language for the entire interview or to even switch between the two. The aim was to allow them to choose the means for expressing their thoughts and to permit the use of the terms that would be most meaningful in their cultural context. The Greek language for all three generations was not only a means of communication. Specific words, terms and expressions were often associated with the Greek culture, Greek Orthodox religion and general

Greek way of life and had stronger emotional content as well as specific nuances that were lacking in the comparable English expressions.

The data that was collected through the 48 interview was coded and categorized based on themes that emerged across the three generations and related to health beliefs and practices. The process of coding was reflected on, checked and was revised as required throughout the process of data analysis. The themes identified in this study are contained in Table 2 along with the area of participants' experience they relate to

Table 2. Themes and Experiential Domains

Themes	Experiential Domains of Participants
1. Transmission / Family	1. Health knowledge and the conceptualization of health
2. Greek Orthodox Religion and Health	2. Religious and identity
3. Greek Culture and Health	3. Cultural identity, language
4. Greek language and the idea of being Greek)	4. Transmission of health knowledge
5. Trust	
6. Food and Health	
7. Health knowledge (education, media etc.)	

Rigor and Validity

Throughout all stages of this study ensuring validity was imperative and various measures were undertaken to measure this. The methodological framework was designed taking into account the need to maintain rigor. The interview process was carried out to include triangulation both across generations within families and across families at the generation level. Further, participants were contextualized based on an in-depth evaluation of their background at the individual and family levels as well as in the context of their community.

To ensure validity of data collected, all interviews were recorded and transcribed immediately to preserve the information and allow for comparison with notes taken by hand during the interview. Validity was further tested by checking the transcripts with the individuals interviewed and asking for clarification of anything that was not clear.

Literature Review on the Topic

Culture and Health

Culture is made up of everyday objects, practices and ways of life that are transmitted within a family and community. Markers, that derive from their way of life and that may be recognized by others, define individuals, groups

and or populations and represent invisible borders that separate them from others. Geertz (1973) notes that culture is a joint and shared way of life. Further, Campos and Johnson (1990) and Spardley (1979) suggest is that culture is, in a sense, a cognitive map that guides the way of life associated to a specific group. Kagawa-Singer, Padila and Asing-Giwa, 2010: 60 note the crucial role that culture plays in wellbeing and also that it provides a lens by which meaning is ascribed to an experience. Edberg (2012) suggests that the concept of culture as a shared way of life can be conceptualized through experience and the feelings and attitudes attached to it. This is where variations are observable, particularly in relation to health. Health and illness are parts of the human experience and are often shaped and guided by culture. For this reason, it is vital for the health care sector, particularly in a multicultural society, to be sensitive to variations and thought processes associated to a specific cultural group and how they may vary from the perceived norm. Dutta (2008) emphasizes the significance of cultural sensitivity and the importance of appropriate health communication programs addressing the specific needs of cultural groups. The culture of a population, and the identity of individuals that is formed by this, is a fundamental part of human existence that is embedded in experience and influences lifelong behavior, attitudes, thought processes, and decision making.

There are various models of health and illness that include the biopsychosocial model, ecological model, and social models. These models explain both health and illness based on a range of factors and influences in the living environment. However, they often overlook the cultural influences on health, separate from social factors. Religion, for example, is a significant aspect of culture that can influence the experience of health and wellbeing and includes a public as well as a private component. Koeing, King and Carson (2012) develop a model of the relationship between health and religion that applies to western religions and is relevant to this study. This model suggests that both the public practice of religion (church attendance, religious activities performed in a group, etc) as well as the private component (faith in God, belief in miraculous events, etc.) has an influence on both health outcomes and health behavior. In this, religion offers a strong basis for the development and maintenance of wellbeing.

The journey of wellbeing is often based on patterns and behaviors that have evolved over time and have been handed down through generations. These ways of life are trusted upon without having a scientific or medical basis (Geertz 1973, Burch 2008, Cole, Stevenson and Rodgers 2009). Many cultural variables, customs and traditions that provide meaning and answers to universally experienced situations derive from the common background of the group involved. One aspect of this is religion which has been shown to be strongly associated with health as a means of coping and resilience (Sherman et al., 2001; Koeing, 2007; Pargament and Cummings, 2010; among others). Studies show that religion provides answers and suggests the meaning of various experiences and may also provide support, comfort, a means of coping and adjustment, and overall positive influences on health and wellbeing (see, for example Pargament, 1997; Tix and Frazier 1998; Murphy, Johnson and Lohan 2003; Ai et al 2004; Pargament and Cummings 2010).

Religiosity and Religion in the Modern World

There has been much research on the topic of family, adult and young people religiosity but I want to draw attention to one undertaken by Petts 2015. That used data from a 2,320 sample size. The findings of this study showed that family structure is not directly related to youth religious outcomes, but that the influence of parental religiosity on religious participation and religious salience (but not closeness to God or private religious practices) was weaker for youth raised in stepfamilies, never-married single-parent families, and cohabiting families than for those raised by married biological/adoptive parents. Results also suggest that less effective religious transmission within non-traditional families compared with traditional families is due (at least in part) to less effective religious socialization within these families.

A modern concept of religion is discussed by Khan 2022 through a gender code which upholds its discursive power and enables the production of religious— and therefore racial—hierarchies. Specifically, the paper suggested religion automatically makes gender present in discourse. Acknowledging religion as an inherently gendered category in this way gives further insight into the discursive power and functioning of the religious label. With the example of the Westphalian production of the “myth of religious violence” and the employment of “religion” in colonial contexts. Religion is both gendered (as part of the Western public/ private binary) and gendering (in colonial contexts vis-a`-vis non-Christian, non-White religions). Acknowledging the multiple ways in which religion is gendered and gen-daring, then, has important bearings on the analysis of religion’s racializing function which is upheld and aided by the gender code through which religion is spoken. In addition, for a mixed method study please refer to Palmer et al (2020) and among African American’s see Hasanpoor-Azghady et al (2019).

Findings, Analysis and Discussion

The findings presented in this paper derive from interviews with the youngest participants of this study, 2nd generation Greek Australian woman. These participants were invited to talk about their understanding of health in light of their cultural background and personal experience. The interviews were undertaken in the English language however code switching did occur, and participants occasionally used or mentioned words in the Greek language that had a direct link to their cultural and religious background. Some examples of such terms are contained in table 2.

Table 3. Examples of Greek Works used and English Translation

Greek word used	Cultural meaning	Religious meaning	English translation
Κήπο	✓		Garden
Χριστιουλη	✓	✓	Jesus
Ευκελαιο	✓	✓	Holy Unction
Λάδι	✓	✓	Oil
Μοναστήρι		✓	Monastery
Αρνί	✓	✓	Lamb
Τσαι του βουνού	✓		mountain tea
Πρόσφορο	✓	✓	offering bread
Παν μετρό αριστο	✓	✓	everything in moderation
Οικονομική κριση	✓		financial crisis
Αυγολέμονο	✓		chicken soup
Ματάκι	✓	✓	evil eye jewellery
Λεμονιά	✓		lemon tree
Παπά	✓	✓	Priest
Πάτερ ημων	✓	✓	Lord's Prayer
Γιαγια / Παπού	✓		grandmother/ grandfather
Χωριό	✓		Village
Χορτα	✓		wild greens

For this generation, health is closely linked to God and His will, but the participants do not see illness as a punishment. Instead, they tend to view it as an element of destiny and fate, an unavoidable aspect of life. This parallels the views of their grandmother and mother, showing transmission of information by the older generations as well as maintenance among younger individuals, who were born and raised in the Australian environment and are fully integrated into that context.

The comments of members of this second Australian generation illustrate this view. One said: *“I never look at illness as a form of a punishment. Everything happens for a reason. When babies die, that’s sad for parents, but it could be a lesson for someone else. God isn’t punishing the baby, but that could be a lesson for someone else.”* Another participant explained: *“When someone has cancer, it could be in their genes but it could have started ages ago. God may have given it to a certain person and put in it their genes and decides when it will appear.”* One spoke of illness as *“for our inner self and how much we are able to deal with. I always used to think that I wasn’t a strong person and I was challenged with stuff in life and I now know that I am way more.”* This participant mentioned that this way of thinking stemmed from her grandmother: *“She [grandmother] has always been on the outside like nice and soft and fluffy and on the inside like rock, and through everything that she has been through, that’s definitely where I get strength.”*

When these participants spoke of the Greek Orthodox religion, the support they found in their faith and the positive emotions it triggered were key to their overall wellbeing. Figure 1 shows some examples of how the 2nd generation Greek Australian participants of this study conceptualize religion as a positive force in their wellbeing and overall affective state.

Figure 1. Religion, Wellbeing and Overall Affective State for 2nd Generation Greek Australian Young Women



When the granddaughters of the immigrants of the Greek diaspora of Melbourne spoke of health, illness and overall wellbeing, cultural perspectives that had been transmitted to them by their older relatives with firsthand experience of Greece and the Greek way of life were observable as central to their beliefs. The perspective of their elders appears to have shaped their understanding of their experience despite the fact that they were born and raised in Australia and only know of their culture as mediated by their elders and also having been significantly influenced by the Australian context and education. The young women who took part in this study were all either finishing high school or newly enrolled in a university degree. All aspired to tertiary study and anticipated having a professional career of some sort. In this, they are similar to other young people of a comparable age from other ethnic and cultural groups in Australia.

The findings of this study suggest that a major aspect of culture that has been passed down from the immigrant generation to young people who are fully integrated into the Australian context is the vital role of the Greek Orthodox religion in health and wellbeing. The 16 young women who took part in this study stress that their faith is a marker of who they are and a symbol of their cultural identity in addition to providing them with comfort, support and resilience through its practices that represent a positive influence on their overall health and wellbeing. This has been noted in the literature for various groups and communities (Sherman et al. 2001, Koeing 2007, Pargament and Cummings 2010). The level of trust the young women in this study place in the views of the older generations is notable and seems to be strongly accepted. One participant said about her grandmother: *"She is just the knowledgeable one. They have been through a lot. They have come from a different life from what we live now and they are old but they are still so healthy. They must*

have been doing something right.” Another noted: “My grandmother is a very resilient person. She is so calm and collected no matter what drama she comes across. Anything you tell my grandmother she has seen it before. She is not surprised by anything. She is very experienced and very wise.” Again, this aligns with similar studies reported in the literature that suggest the strength of traditional views in certain cultural communities (Geertz 1973, Burch 2008, Cole, Stevenson and Rodgers 2009, Edberg 2012).

For the elders of the Melbourne Greek community, religion has often been the key to their adjustment and adaption to migration in the face of illness or challenges in life. This function, in addition to specific practices and religious customs, has also been transmitted to their granddaughters who derive the same type of social support that appears to be key in their emotional health and wellbeing. Interestingly, the young women who took part in this study were similar in age to their grandmothers at the time of their migration to Australia. This was noted by some of the participants and was seen by them as an indication of their grandmother’s resilience and strength. One said: “It would have however been very difficult when she left, she was my age now and I could never had done that. She was very tough and still is”

Table 4. Some Remedies know to Young Women in Diaspora

<u>Some general health remedies</u>
“For stomach cramps, Mum gives me a towel and puts methylated spirits on it, and I put it on my tummy and, after a half an hour, it’s gone, the pain.”
“Ouzo, to gargle ouzo when feeling unwell, your throat, like Listerine.”
“Once my brother got stung by a bee, and I think yiayia (Γιαγιά) [grandmother] put vinegar on it - I don't know why.”
“I don't remember what it's called in English, but Mum called in the kompresa (κομπρέσα) [compress]. It was a dish cloth in alcohol if you had a sore tummy.”
“They would put natural Greek yogurt to fill out their hair. You put natural Greek yogurt in your hair, you leave it in as a treatment and it fills your hair out. It’s for hair loss. My grandmother from heavy stress lost her hair overnight. The yogurt, my uncles, they all do it, Greek natural yogurt in their hair.”
“Vinegar for mosquito bites, that’s from my grandmother.”
“Butter on burns.”
<u>Plants and Herbs</u>
“My grandfather eats raw ginger as a preventative for getting sick. I'm pretty sure he gets this from watching the Greek channel.”
<u>Honey</u>
“If you had a really bad sore throat, my grandfather does this thing were you get a little bit of whiskey and honey and, I think, lemon, and he would gargle it.”
“I always have χαμομήλι (chamomile tea) with honey; honey has a lot of healing qualities to it. You always have Manuka honey when you feel sick.”
“Sore tummy – mountain tea or chamomile tea.”
<u>Oil</u>
Has used the oil from the Holy Unction on her wrist when she was experiencing pain, and this is something that she will use in the future

And for some quotes from these young women who uniformly, stated that illness was not a punishment from God but allowed that it could be a lesson. “I never look at illness as a form of a punishment. Everything happens for a reason. When babies die, that’s sad for the parents, but it could be a lesson for someone else. God isn’t punishing that baby, but that could be a lesson to someone else.”

“Illness is a challenge] for our inner self and how much we are able to deal with. I always used to think that I wasn’t a strong person and I was challenged with stuff in life and I now know that I am way more.” She mentioned that this belief and way of thinking came from her grandmother. “She [grandmother] has always been on the outside, like nice and soft and fluffy, and on the inside, like rock, and through everything she has been through, that’s definitely where I get strength.”

The young participants in held the same religiously-based views on the origin of disease that their mothers and grandmothers did. This is likely to be attributable to the fact that they grew up in the Greek-Australian community where such views are generally held by most individuals. The participants strongly believed that “everything happens for a reason,” a view also expressed by their elders.

“It’s just predetermined and just the way things are meant to be.”

“God does not make people sick. Scientifically, that does not make sense to me. The choices we make in life is what determines that.”

These young women were divided on the issue of fate, luck and destiny. “What I have been taught is, in our religion, everything happens for a reason and they happen from God.” Another young woman however said “I don’t believe in fate as we can also make decisions.” However, reflecting what may be a general concern about cancer in the Greek community, several of the participants mentioned this disease in discussing God’s role in health and illness. “When someone has cancer, it could be in their genes but it could have started ages ago. God may have given it to a certain person and put it in their genes and decides when it will appear.” “If someone contracts a disease somehow, and God lets that go ahead for some reason, but He doesn’t say ‘you’re going to get cancer’.”

These young women were also aware of the evil eye jewellery that can be bought in many stores around Melbourne. One said, “I don’t even get the jewellery, with the eye on it. It’s so scary. Fair enough, if it’s a fashion statement, but I don’t think it will actually protect you from sickness or harm. Another on this topic said “I definitely believe in the *mati* (μάτι) [evil eye] and I have my *mati* (μάτι) [evil eye] bracelets. I believe that, if you lose it, the *mataki* (ματάκι) [evil eye jewellery], it has done its job for you. It protected you from something and has done its job.”

Several of the younger participants in this study admitted that they believe in another kind of evil that is more serious than the evil eye and that cannot be addressed by folk practices. Part Saing, “Black magic is out there. Acknowledge that it exists but don’t give it too much power. That’s the way I was raised. Acknowledge that it’s there, but it’s not something that can be fixed with a Panadol. For this, you go to an elder, a grandmother or a priest, depending on the level of it. For something very serious, you go to a priest. For something like a possession, you go to a priest. They can do more than what a doctor can do.” These young women generally understand the concept of evil, associated with the devil or with demons, as being on a continuum with lesser supernatural effects like

the evil eye. This represents a religious interpretation but, for those of the participants who believe in it, is also mixed with folk practices and elements of belief that are outside the teachings of the Orthodox Church and, in some cases, outside the Greek tradition.

Conclusion

The older participants in this study were anxious to convey their health knowledge to their children and grandchildren and to have their younger relatives follow their advice. This advice tends to center of food and diet choices; religious observance and practices, including as a means for dealing with adversity; and maintaining the Greek way of life which they see as more advantageous for health. They tend to view this process as one way, with information flowing from them, as the older, wiser family member, to the younger ones who have less knowledge. “I don’t need my children to tell how to look after my health. They’re always telling me to take it easy.”

The older women who took part in this study have been in Australia from 39 to 56 years. Most of them never mastered English to a high level and generally do not use the language in their daily affairs. As the participants themselves noted, this has been possible because of the large and very strong Greek community in Melbourne that has served to insulate them from the surrounding, English-speaking public. Chart 1 below indicates the language of choice reported by these older women.

Chart 1. *Self-reported Use of Greek by Members of the Immigrant Generation*



The participants seem to trust what their mothers, parents, grandparents and other elders told them in Greece and rely upon the food and knowledge they were raised with to maintain their health. “Wild greens, meat but not too much, the knowledge I have from Greece as I was raised in the village and everything was fresh and homegrown.” This participant felt that this lifestyle was the reason people were very healthy in her childhood and why there were fewer illnesses than there are now. While it is likely that, as teenage girls, these participants were not aware of the full health status of older people in their village in Greece and also that clinical diagnosis of various conditions was less common, their perception of Greece as healthier than Australia is very strong, and the participants would like to share their knowledge about health with their children and grandchildren. Several, however, are reluctant to do so as they felt their advice would not be accepted by their younger relatives.

The older participants in this study were generally reluctant to take the health advice provided by their daughters and granddaughters but do view information from these family members as more reliable than from strangers. The participants recognize that their daughters and granddaughters are well-meaning but feel that they do not necessarily know how the participant should take care of herself. "My granddaughter gives me health advice but she is not always correct as she always wants to lose weight." Another mentioned "My daughter tells me that, at my age, I shouldn't fast, and I tell her that I will fast and, if I realise that my health is impacted, I will stop. When I fast, I see no difference in my health as I still eat. I'm not on a diet, like the people who diet, and they don't eat and faint." One participant related how her children and grandchildren were always telling her to give up her garden because they were afraid she might fall and that her health was more important than her vegetables. This advice, while well-meaning, was also unwanted because the garden was an important link to her culture for this participant.

One area where the older participants in this study were willing to accept advice from their daughters and granddaughters was in connection with technology which, for many of them, has come to be an important source of emotional support and that playing games on her mobile phone helps when she is anxious. This was taught to her by her grandchildren. Similarly, many of these older women have learned to use iPads, Skype and e-mail from their children and grandchildren. "My daughter showed me how to use the iPad and, if I have any difficulties, I ask my daughter or grandchildren for help. I really like my iPad, and I have the other one as well, the one that you see, Skype."

The findings of this study demonstrate the vital role that culture and cultural identity may have for individuals and populations. For the young women who took part, the elements of Greek culture and religion they learned from their mothers and grandmothers is central to both their conceptualization of health and wellbeing and also to its development and maintenance. For these young women, who are English speaking and have grown up in Australia, their knowledge of Greece and its religion and culture has come entirely from the direct and indirect influence of their elders and observation of their way of life. This is significant in that it demonstrates the durability of Greek identity for this population, despite the potentially interfering presence of other cultural elements in the community in which they live, and also the level of trust and reliance they place on their elders. For this group of young women, as for their grandmothers, religious faith and practice and the perceptions that derive from them, serve as an extremely important source of resilience as well as a significant marker of their personal identity and cultural belonging.

The findings of this study suggest that there is important insight to be gained from a deeper and more nuanced understanding of the way in which culture affects various aspects of individual experience, especially as relates to health and wellbeing. This study for example, revealed unanticipated aspects of the health experience of the women involved, suggesting that the experience of male members of the same and other diaspora communities may be as informative. Work of this kind would support a better understanding of the experience and perceptions of migrants as well as the process of acculturation.

This study also pointed up the importance of religion as the source of a cognitive framework that remains significant among younger community members. This aspect of understanding may have additional aspects that did not emerge in this research and that may also vary in different communities. Further study of the experience of modern Greek Orthodox practice and faith among the young would help to expand our understanding of religion among younger people and might also suggest strategies and approaches that will support and build resilience that lasts a lifetime. Additionally, as this study was conducted in Melbourne, Australia, it did not allow for a comparison of experience across Greek communities. In particular, it would be very beneficial to carry out similar research in Greece itself to investigate the ways in which the culture and practices, related both to health and to other areas of experience, have developed there and compare them to the comparable views in diaspora communities. This approach would be especially helpful in understanding the identity pressures felt by younger members of the community and would offer additional insight into the relationships between Greeks in their homeland and those living in other places.

References

- Ai AL, Peterson C, Tice TN, Bolling SF, Koenig HG (2004) Faith-based and Secular Pathways to Hope and Optimism Subconstructs in Middle-aged and Older Cardiac Patients. *Journal of Health Psychology*, 9(3), 435-450. doi:10.1177/1359105304042352
- Avgoulas M (2013) "The Greek diaspora of Melbourne, Australia". *Polidhromo - Periodical for Bilingualism and Multiculturalism in Education and Society*. 6(1) 54-58
- Burch S (2008) *Cultural and Anthropological Studies*, in Health Studies: An Introduction. Palgrave Macmillian, 186-229
- Christou A (2001) *The Struggle, Success and National Consciousness of the Greek Diaspora in America*, in Lena Koski and Katri Pajala (eds), *American Studies at the Millennium: Ethnicity, Culture and Literature*, Finland University of Turku, pp. 125-135
- Campos SS, Johnson TM (1990) *Cultural considerations*. In B. Spilker (Ed.), *Quality of life in clinical trials* (pp. 163-170). New York: Columbia University Press.
- Cole E, Stevenson M, Rodgers B (2009) The influence of cultural health beliefs on self reported mental health status and mental health utilization in an ethnically diverse sample of older adults. *Journal of Feminist Family Therapy: An International Forum*, 21, 1-17
- Dutta M (2008) *Communicating Health: A Culture-centered Approach*. Polity.
- Edberg AM (2012) *Essentials of health, culture and diversity: Understanding people, reducing disparities*, ed. R. Riegelman. Burlington, MA: Jones & Bartlett Publishers.
- Geertz C (1973) *The Interpretation of cultures: Selected essays*. Basic Books
- Georgas J, Berry JW, van de Vijver FJR, Kagitcibasi C, Pootinga YH (2006) *Families across cultures: A 30-nation psychological study*. New York: Cambridge University Press.
- Hasanpoor-Azghady SB, Simbar M, Vedadhir AA, Azin SA, Amiri-Farahani L (2019) The social construction of infertility among Iranian infertile women: a qualitative study. *Journal of reproduction & infertility*, 20(3), 178.
- Kaloudis G (2006) Greeks of the diaspora: modernizers or an obstacle to progress? *International Journal on World Peace*. Retrieved from <http://www.highbeam.com/doc/1G1-158528228.html>
- Kagawa-Singer M, Padilla GV, Ashing-Giwa K (2010) Health-Related Quality of Life and Culture. *Seminars in Oncology Nursing*, 26(1), 59-67. doi:10.1016/j.soncn.2009.11.008

- Khan RM (2022) Speaking “religion” through a gender code: The discursive power and gendered-racial implications of the religious label. *Critical Research on Religion*, 10(2), 153-169.
- Koenig HG (2007) Religion and remission of depression in medical in patients with heartfailure/pulmonary disease. *The Journal of Nervous and Mental Disease*, 195(5), 389–395. doi:10.1097/NMD.0b013e31802f58e3
- Koenig H, King D, Carson V (2012) *Handbook of religion and health*. Oxford University Press.
- Murphy SA, Johnson LC, Lohan J (2003) Finding meaning in a child’s violent death: A five-year prospective analysis of parents’ personal narratives and empirical data. *Death Studies*, 27, 381-404
- Palmer Kelly E, Hyer M, Payne N, Pawlik TM (2020) A mixed-methods approach to understanding the role of religion and spirituality in healthcare provider well-being. *Psychology of Religion and Spirituality*, 12(4), 487.
- Pargament KI, Cummings J (2010) *Anchored by Faith: Religion as a Resilience Factor*, in Reich, JW, Zautra, AJ and Hall, JS, eds, *Handbook of Adult Resilience*, The Guilford Press, New York and London, 193-212.
- Pargament KI (1997) *The Psychology of Religion and Coping: Theory, Research, Practice*.
- Pauwels A (2005) Maintaining the Community Language in Australia: Challenges and Roles for Families. *International Journal of Bilingual Education and Bilingualism*, 8(2-3), 124-131. doi:10.1080/13670050508668601 Guilford Press.
- Richard JP (2015) *Sociology of Religion*, Volume 76, Issue 1, 95–120, <https://doi.org/10.1093/socrel/sru064>
- Sherman AC, Simonton S, Adams DC, Latif U, Plante TG, Burns SK, Poling T (2001) Measuring religious faith in cancer patients: reliability and construct validity of the Santa Clara strength of religious faith questionnaire. *Psycho-Oncology*, 10(5), 436–443. doi:10.1002/pon.523
- Smolicz JJ, Secombe ME, Hudson DM (2001) “Family Collectivism and Minority Languages as Core Values of Culture among Ethnic Groups in Australia,” *Journal of Multilingual and Multicultural Development*, 22 (2): 152-172.
- Spradley JP (1979). *The ethnographic interview*. FortWorth, TX: Harcourt Brace Jovanovich.
- Tamis AM (2005) *The Greeks in Australia*, Cambridge University Press, Cambridge and New York.
- Tix AP, Frazier PA (1998) The use of religious coping during stressful life events: main effects, moderation, and mediation. *Journal of Consulting and Clinical Psychology*, 66(2), 411–422.
- Tsolidis G, Pollard V (2010) Home Space: Youth Identification in the Greek Diaspora. *Diaspora, Indigenous, and Minority Education*, 4(3), 147-161.

Appendix 1 **Interview Schedule**

The Transmission of Culturally Determined Health Beliefs among Three Generations of Greek families in Melbourne, Australia

General questions for all participants:

1. *What does it mean to be healthy? (We want to know what you think “healthy” means).*
2. *How can you tell if someone is healthy or sick? Are there observational signs?*
3. *What foods are most healthy? How do you know?*
4. *What foods are unhealthy? How do you know?*
5. *Can we improve/protect our health by eating certain things? (fasting)*
6. *Does God make people sick? Why?*
7. *Are religious people more likely to be healthy? Why?*
8. *Is being sick a punishment from God? For what?*
9. *Are there religious teachings about disease and health?*
10. *How is illness treated in your family? Are there any specific remedies used in your family?*
11. *Are there diseases that cannot be treated by doctors? What examples?*
12. *How do you treat illnesses in your family without going to the doctor?*
13. *Are there diseases or illnesses that are specific to Greek people?*
14. *What do you think about magic?*
15. *What do you do to stay healthy?*
16. *Are there things in your environment that you think are unhealthy? What are some examples?*

Specific questions for grandmothers (migrant generation)

1. *How was illness treated in Greece when you were a child?*
2. *When you were sick as a child did you go to the doctor?*
3. *How was illness treated in Greece by your parents?*
4. *What are some folk remedies that you may remember from your mother (fever, cuts or specific remedies).*
5. *Have you used or are you aware of any medical plants to treat illness?*
6. *Was illness treated differently in Greece than in Australia?*
7. *Did you eat different food when you lived in Greece?*
8. *What have you tried to maintain and hand down to the younger generations about the Greek way of life?*
9. *What do you remember about your first few years in Australia?*
10. *Did migrating to Australia impact your health?*
11. *How many years after migrating to Australia did you return to Greece?*
12. *How often do you visit Greece? And why?*
13. *Have you been to Greece with your children? And/or your grandchildren?*

14. *Is the way of life different in Greece to Australia? How? Why?*
15. *Have any of your health lifestyle habit's changed since migrating and what may have influenced these changes?*
16. *Are you a member of any Greek groups and/or clubs?*

Specific questions for the 1st and 2nd generation

1. *What has you mother and or/grandmother told you about how illness was treated in Greece?*
2. *Do you know if your mother/and or grandmother went to doctors as a child in Greece?*
3. *Do you know how illness is treated in Greece?*
4. *What has your mother and/or grandmother told you about her first few years in Australia?*
5. *Do you think migrating to Australia has impacted her health?*
6. *Have you been to Greece? If yes, how old were you and with whom did you go? What do you remember about Greece is it similar to what your mother or grandmother has told you? If no, why? Would you like to visit Greece? If yes would you like to go to Greece again?*
7. *What do you know about the way of life in Greece- is it different to the Greek way of life in Australia? Do you know of any Greek remedies (health beliefs) and from whom? Do you use them and trust them? Have you taught your mother and or grandmother any non-Greek remedies? If yes do they use them?*
8. *Do you have many Greek friends?*
9. *Have you shared your Greek culture (customs, traditions, health beliefs) with any of your non Greek friends?*
10. *Are you a member of any Greek clubs or groups? Why? If yes have these groups provided you with a link to your Greek heritage*
11. *What has your experience been as a 1st or 2nd generation Australia? School and what they may have learnt from their mother or grandmother about the Greek culture (language, food, cooking)*
12. *Did you go to Greek school? Why? Did you like it?*
13. *Is it important for you to maintain the Greek way of life? Why? How? Would this be or has it been challenging?*