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Maternal health disparities linked to stressful life events: a cross-sectional study of industrialized Italian cities

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Abstract

Background Understanding the impact of family life stressors on maternal health is crucial, particularly in highly industrialized areas. This study assessed the validity of an Italian-language version of the Crisis in Family Systems-Revised (CRISYS-R) survey in Northern and Southern Italian cohorts.

Methods Mothers (n = 252) completed an Italian version of CRISYS-R, translated from English using the forwardbackward method. At least 14 days after initial survey completion, a random subset of mothers (n = 44) retook CRISYS-R. Information about family demographics, socioeconomic status, and maternal health were collected by selfreport on structured surveys. Statistical analyses were performed in R.

Results Test-retest analysis yielded a Pearson coefficient of 0.714 (Brescia: 0.845, Taranto: 0.726). Cronbach's alpha coefficient for internal consistency was 0.765 (Brescia: 0.718, Taranto: 0.784). In multivariable regression, the total number of stressors reported on the initial CRISYS-R test was positively associated with: poor maternal mental health (p < 0.001), poor maternal physical health (p < 0.01), and residence in Southern rather than Northern Italy (p = 0.02). Univariate correlations yielded similar results, plus a negative correlation between annual family income and total life stressors (p < 0.05).

Conclusions Statistical analyses support the validity and reliability of an Italian-language CRISYS-R in industrialized areas, while highlighting relationships between family stress and maternal mental and physical health. This survey instrument has the potential to inform public health policies and interventions serving families in Italian-speaking areas with high burdens of industrial pollution.

Keywords Public health practice, Environmental pollution, Family health, Women's health, Crisis in family systems, Social determinants of health, Psychological determinants of health, Maternal mental health, Italy

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Introduction

Family life stressors – including job loss, food insecurity, and medical illness – pose significant health risks to individuals and communities [1]. Particularly for mothers and children, family stress is associated with long-term mental and physical health outcomes [2], so measuring the burden of family life stress is integral to maternal-child health programming and policy. Validated instruments that measure multiple domains of life stressors can inform strategies to promote population health [3, 4].

While evidence suggests that mitigating family life stressors is a valuable preventive strategy [5], finding accurate and reliable stress measurement tools remains challenging. Specifically, measurement tools that identify family life stressors and evaluate the adversity and distress they cause are essential to a complete understanding of how stress mediates social determinants of health and health inequities.

The Crisis in Family Systems-Revised (CRISYS-R) questionnaire was developed in 2001 to capture contemporary realities of family life stress [6]. CRISYS-R is validated in ethnically diverse cohorts of English and Spanish speakers [7] with strong test-retest reliability and internal consistency, and has been successfully applied to mothers and children of diverse income classes [8]. A 2021 study demonstrated that cumulative life stressors captured by CRISYS-R were associated with epigenetic changes in breast milk microRNA, which induce epigenetic changes in infants [9]. A study of Black families in the United States showed a positive relationship between parental appraisal of safety-related stressors on CRISYS-R and rates of obesity (a stress-responsive pathology) in their adolescent offspring [10]. Another study found that high stress levels on CRISYS-R correlated with altered stressrelated endocrine signaling among pregnant women [11].

Beyond identifiable stressors captured on CRISYS-R, adverse maternal-child health outcomes are elicited by latent stressors, including chronic air pollution exposure [12, 13]. Like many European cities [14], the Italian metropolitan areas of Brescia and Taranto face large-scale environmental health problems from industrial pollution. Industrial pollution is defined as the contamination of air, water, soil, and/or crops with byproducts of largescale manufacturing activity that are known to harm human health, such as fine particulate matter, heavy metals, ground-level ozone, carbon monoxide, and sulfur dioxide. In Brescia, for instance, where large ferroalloy mining, extraction and processing operations occur, an increased prevalence of neurological illness has been described in relation to heavy metal contamination of soil and the water supply. In Taranto, the operations of an enormous steel manufacturing complex have been linked to unsafe levels of air pollution and an elevated incidence of cancer for multiple generations [15-18]. However, little remains known about the combined effects of family life stress and chronic pollution exposure.

Presently, few Italian-language instruments are validated to quantify family life stress, thereby limiting maternal-child health research. Moreover, stark disparities in socioeconomic resources, healthcare, and culture separate Northern Italy from Southern Italy, so measurement instruments must be validated in both populations.

This study of families in the industrialized Italian regions of Brescia and Taranto aimed to assess the validity of an Italian-language CRISYS-R questionnaire and explore the relationship of family life stress to maternal health and sociodemographic attributes.

Methods

Study design & population

This study is nested within the Impact on Health of Exposure to Environmental Pollutants in the Brescia and Taranto Areas (ISEIA) study, a cross-sectional investigation of behavioral and neurocognitive effects of pollution on families of school-aged children in industrialized Italian regions. ISEIA includes 430 children aged 6–14 years (Brescia: n = 130, Taranto: n = 300) and their parents, enrolled from December 2017 to December 2020. All participants spoke Italian. All participants had resided in the study area since the beginning of the child's gestational period. Families of children with neurodevelopmental disease, disabling visual or motor impairments, and/or conditions interfering with the accumulation, metabolism and elimination of pollutants were excluded.

For the present study, a random subset of motherchild pairs from the ISEIA cohort completed additional questionnaires about socioeconomic status and health. To assess family life stress, the Italian-language CRISYS-R was administered to mothers in this subgroup. This study was conducted according to the Declaration of Helsinki and was approved by the Institutional Review Boards of the Italian provinces of Brescia (NP2604; July 27, 2017) and Brindisi (N45/17; November 17, 2017). Written informed consent was obtained from all adult participants. For child participants (who were all under the age of 16), written informed consent was obtained from a parent or legal guardian and assent was obtained directly from the participating children. Informed consent included permission to publish study findings and was obtained prior to study enrollment.

Data collection

After appropriate information and instruction, consenting parents were sent a secure online link, by which they completed five questionnaires: socio-demographic information, CRISYS-R [6, 8], Patient Health Questionnaire-9 (PHQ-9) [19], 12-Item Short-Form Health Survey (SF-12) [20], and MacArthur Scale of Subjective Social Status [21]. De-identified data was collected in the Research Electronic Data Capture system.

CRISYS-R is a 63-item questionnaire about stressful events in 11 life domains (financial, legal, career, relationships, home safety, community safety, self-related medical issues, others' medical issues, domestic, law enforcement interactions, and discrimination). Participants indicate whether their family experienced each stressor in the past 6 months. Details about CRISYS-R are described elsewhere [6, 8]. CRISYS-R was translated from English to Italian via forward-backward translation by two psychologists, who were also native Italian speakers. Among the metrics derived from CRISYS-R, the total number of reported stressors was the dependent variable for validation, consistent with prior studies [7]. The remaining survey instruments are described in detail elsewhere [19–21].

The Patient Health Questionnaire-9 (PHQ-9) is a short scale used in clinical medicine for diagnosis, monitoring and determining the clinical severity of depression. The PHQ-9 is suitable for both screening and for case-finding: it can be administered by medical professionals, trained personnel, or self-administration. The PHQ-9 survey investigates the presence, in a timeframe of two weeks, of the nine symptoms of depression listed in the Diagnostic and Statistical Manual-V. Each symptom is rated on a 4-point scale based on frequency, ranging from never to nearly every day. The survey also assesses the extent of functional impairment caused by depressive symptoms. A high score corresponds to a more significant impairment, with scores ranging from 0 to 27. Scores between 5 and 9 indicate the presence of mild or sub-clinical depression, whereas a score of 10 or greater suggests clinically relevant depression, with the severity of disease increasing proportionally to the numerical score.

The 12-Item Short-Form Health Survey (SF-12) measures the functional health status of adults using two physical and mental health component scales. The SF-12 is composed of 12 items about general health, activity, and social limitations, pain, and emotions, which are derived from the 36 items of the original SF-36 questionnaire. The subject is asked for a self-assessment of their level of functioning in carrying out standard day-to-day living activities on the day of questionnaire administration and in the previous 4 weeks, with lower scores corresponding to worse health conditions. The SF-12 is a highly versatile, validated health assessment that is widely used for both clinical and epidemiological purposes.

The 11-item MacArthur Scale of Subjective Social Status (MacArthur SSS Scale) comprehensively assesses socioeconomic status (SES). It is a measure of families' objective financial resources and perceived social standing, reflecting impressions of current circumstances, underlying variables, and future opportunities. The interviewee is asked to provide socioeconomic data, including occupation and working conditions, income bracket, and number of family members. Moreover, the MacArthur SSS scale utilizes the visual aid of a 10-step ladder, whereby respondents visually indicate their perceived position in the socioeconomic hierarchy of their community and of the broader Italian population in regard to income, education level, occupation, and other variables. This scale adds valuable information about both objective and perceived measures of SES, which together are more predictive of health and well-being than objective measures alone. While measurable levels of education, job prestige, and income have been linked to mental and physical health, higher levels of subjective social status (SSS) are also health-promoting. The MacArthur SSS scale is accessible to those with low financial literacy and/ or hesitation to provide details about personal finances by offering "I don't know" and "I don't want to answer" choices. In the case of an "I don't know" or "I don't want to answer" response, the item was treated as missing.

Hypotheses

Higher quantities of family life stressors reported on CRISYS-R were hypothesized to correlate directly with worsened maternal mental and physical health outcomes (higher PHQ-9 scores, lower SF-12 scores) and with lower annual family income and family net worth. Magnitude of correlation was expected to be stronger for mental health than for physical health variables. To a lesser extent, family life stressors were expected to correlate with low education levels and manually laborious occupations, and residence in Taranto rather than Brescia (given overall higher rates of poverty and adverse health outcomes in Taranto). Variables hypothesized to be unrelated to total CRISYS-R stressors were: child age, child sex, maternal age, and paternal age.

Analysis

Descriptive statistics were generated for all continuous and discrete variables. A linear relationship between the dependent variable (total reported incidents on CRISYS-R) and each independent variable was verified via generalized additive modeling. Welch two-sample t-tests (continuous variables) and chi-squared tests (discrete variables) were performed to ascertain any significant differences between subgroups (i.e. Brescia vs. Taranto participants; test-only vs. test-retest participants).

Test-retest reliability For participants who took both the initial CRISYS-R test and a follow-up retest, test-retest analysis was performed to ascertain the reliability of the Italian-language CRISYS-R [22]. An interval of 14 to 54 days (μ =22.6) occurred between test administrations. Based on prior mental health literature, a Pearson corre-

lation coefficient of 0.7 or above was considered adequate test-retest reliability [23]. Data were verified for normality.

Internal consistency Cronbach's alpha coefficients described the internal consistency of participants' responses to the Italian CRISYS-R questionnaire [22]. Per literature, a Cronbach's alpha value of 0.75 or above was considered strong internal consistency; coefficients between 0.65 and 0.75 were considered acceptable [24, 25].

Construct validity Univariate correlations and multivariate linear modeling assessed the construct validity of total CRISYS-R stressors by evaluating both convergence with stress-related variables (convergent validity) and divergence from non-stress-related variables (discriminant validity) [22]. All covariates listed in *Hypotheses* were tested as independent variables. Beta coefficients, 95% confidence intervals, and *p*-values were calculated for each model.

First, multivariate linear regression models were fitted so that the total number of CRISYS-R stressors was predicted by combinations of the covariates found to be significant in univariate analysis, plus associated interaction terms. In a second analysis, variable selection was performed via a stepwise approach and continuous variables were standardized. Redundant variables were not included in the same model. Differences were statistically significant at p < 0.05 for a two-tailed hypothesis test. Analysis was conducted in R 4.3.1.

Results

Cohort description

Characteristics of participating families (n = 252) are summarized in Table 1. The cohort was well-balanced by child sex and region. The majority of responding families who provided information about parental education and income had not completed post-secondary education (74.2% of mothers, 82.6% of fathers) and had annual incomes below 50,000 euros (66.1%). Among families providing occupational information, 51.4% of mothers were not formally employed whereas 47.5% of fathers performed manual labor. On the maternal PHQ-9 survey (n = 233), 73 (31%) mothers indicated some clinical depression: 50 (21%) had mild depression (PHQ-9 score 5 to 9), 21 (9%) had moderate depression (scores 10 to 14), and 2 (0.9%) had severe depression (scores above 14).

In terms of sociodemographic characteristics, four interregional differences emerged. First, Brescia families had younger children (Brescia mean: 8.6 years, Taranto mean: 11.8 years, p < 0.0001 by t-test). Second, Taranto families reported a greater number of total stressors on CRISYS-R (Brescia mean: 4.0, Taranto mean: 5.0, p = 0.03 by t-test). Finally, Taranto families reported lower annual

Between test-only families (n = 208) and test-retest families (n = 44), no significant differences existed for any measured socio-demographic variable, except that test-retest families exhibited lower maternal PHQ-9 scores (test-only mean: 3.89, test-retest mean: 2.89, p = 0.03 by t-test).

Test-retest reliability

Table 2 describes test-retest analysis, measured by Pearson product-moment correlation coefficient (r). The combined cohort and regional subgroups demonstrated Pearson product-moment correlation coefficient values above the established confidence threshold of r = 0.70.

Internal consistency

Table 2 also describes internal consistency analysis, measured by Cronbach's alpha coefficient (a). The overall cohort and Taranto subgroup produced Cronbach's alpha coefficient values above 0.75, indicating strong internal consistency. The Brescia subgroup produced an alpha coefficient value between 0.65 and 0.75, indicating acceptable internal consistency.

Construct validity: univariate

Notable Spearman's rank correlation coefficients (ρ) predicting total CRISYS-R are described below. Of note, variables did not satisfy conditions of normality per the Shapiro-Wilk test:

- **SF-12 Total Score**: *ρ* = -0.19 (*p* = 0.008 by nonparametric test).
- SF-12 Physical Health Sub-score: ρ = -0.23 (*p* = 0.001 by nonparametric test).
- SF-12 Mental Health Sub-score: ρ = -0.16 (p = 0.025 by nonparametric test).
- **PHQ-9 Score**: $\rho = 0.24 \ (p = 2.8 \times 10^{-4} \text{ by} \text{ nonparametric test}).$

When controlling for regional affiliation via linear regression modeling, each maternal health variable continued to be a statistically significant predictor of total CRISYS-R stressors:

- SF-12 Total Score: β = -0.24, p = 1.60 × 10⁻⁵; Region: β = 1.21, p = 0.027.
- SF-12 Physical Health Sub-score: β = -0.53, p = 0.0001; Region: β = 1.15, p = 0.039.
- SF-12 Mental Health Sub-score: β = -0.31, p = 0.0001; Region: β = 1.31, p = 0.018.
- PHQ-9 Score: β = 0.32, p = 4.99 × 10⁻⁵; Region: β = 1.09, p = 0.029.

Table 1 Description of study population

	Full Cohort	Brescia	Taranto
	252	101	151
Child Variables			
Age, years	11 (9, 12)	8 (7, 10)	12 (11, 12)
median (IQR)			
Female sex	145 (57.5)	54 (53.5)	91 (60.3)
n (%)			
Maternal Variables			
Age, years	44.3 (41.2, 47.7) n = 125	46.3 (43.3, 50.3)	44.1 (40.9, 47.6)
Education level	n = 132	n=9 n=0	n = 120
n (%)	11-152	11-9	11-125
Primary or secondary	24 (18.2)	2 (22.2)	22 (17.9)
education			
Vocational school	9 (6.8)	2 (22.2)	7 (5.7)
High school diploma	65 (49.2)	3 (33.3)	62 (50.4)
Some college or higher	34 (25.8)	2 (22.2)	32 (26.0)
Occupation	n=138	n=9	n=129
n (%)			
Homemaker or	71 (51.4)	4 (44.4)	67 (51.9)
Professional	28 (20 2)	2 (22 2)	25 (10 4)
Employee	17 (123)	1 (11 1)	25 (19.4) 16 (12.4)
conceptual labor	17 (12.3)	1 (11.1)	10(12.4)
Employee,	22 (15.9)	1 (11.1)	21 (16.3)
manual labor			
PHQ-9 Score	3.70 (3.23)	3.79 (3.00)	3.63 (3.40)
mean (SD)	n=233	n=100	n = 133
SF-12 Total score	38.75 (5.04)	39.18 (4.09)	38.36 (5.76)
mean (SD)	n = 198	n = 94	n = 104
SF-12 Merilai nealth sub-score mean (SD)	21.38(3.51) n = 198	21.55(2.95) n = 94	21.23(3.90) n = 104
SF-12 Physical health sub-score	17 36 (2.08)	1763 (161)	17 12 (2 41)
mean (SD)	n=198	n = 94	n=104
Paternal Variables			
Age, years	47.4 (44.1, 51.3)	49.3 (44.4, 50.3)	47.29 (44.0, 51.3)
median (IQR)	n=128	n=9	n=119
Education level	n=132	n=9	n=123
n (%)	41 (21 0)		20 (20 0)
Primary or secondary	41 (31.0)	3 (33.3)	38 (30.9)
Vocational school	8 (6 5)	1 (11 1)	7 (5 7)
High school diploma	60 (45.5)	4 (44.4)	56 (45.5)
Some college or higher	23 (17.4)	1 (11.1)	22 (17.9)
Occupation	n=138	n=9	n=129
n (%)			
Unemployed	7 (5.1)	0 (0)	7 (5.4)
or retired			
Professional	25 (18.1)	2 (22.2)	23 (17.8)
Military official	25 (18.1)	0 (0)	25 (19.4)
Employee,	16 (11.6)	2 (22.2)	14 (10.9)
	65 (47 1)	5 (55 5)	60 (16 5)
manual labor	(1.1+) CO		00 (40.3)
Family Variables			
Annual family income, euros	n=171	n=81	n = 90
n (%)			

Table 1 (continued)

	Full Cohort	Brescia	Taranto
Low: €0 to €24,999	61 (35.7)	19 (23.5)	42 (46.7)
Medium: €25,000 to €49,999	52 (30.4)	28 (34.6)	24 (26.7)
High: €50,000 or above	23 (13.5)	18 (22.2)	5 (5.6)
Unknown or	35 (20.5)	16 (19.8)	19 (21.1)
declined to answer			
Family net worth, euros n (%)	n = 171	n=81	n = 90
€0 to €4,999	54 (31.6)	20 (24.7)	34 (37.8)
€5,000 to €19,999	18 (10.5)	11 (13.6)	7 (7.8)
€20,000 to €49,999	14 (8.2)	8 (9.9)	6 (6.7)
€50,000 or above	13 (7.6)	12 (14.8)	1 (1.1)
Unknown or	72 (42.1)	30 (37.0)	42 (46.7)
declined to answer			
CRISYS-R:			
<i>Total incidents</i>			
median (IQR)			
Initial Test	3.5 (1.0, 7.0)	3.0 (1.0, 6.0)	5.0 (1.0, 7.0)
	n=252	n=101	n=151
Initial Test:	4.0 (1.0, 8.0)	4.0 (2.0, 6.75)	5.0 (1.0, 9.0)
Test-retest group only	n=44	n=22	n=22
Retest:	2.5 (1.0, 6.0)	3.5 (1.25, 6.0)	2.0 (IQR 0, 4.0)
Test-retest aroun only	$n - \Lambda \Lambda$	n-22	n - 22

SD=standard deviation, IQR=interquartile range; PHQ-9=Patient Health Questionnaire-9; SF-12=12-Item Short Form Health Survey; CRISYS-R=CRISYS in Family Systems-Revised

Table 2 Test-retest and internal consistency analysis of total reported stressors in CRISYS in Family Systems-Revised questionnaire

	Full Cohort	Brescia	Taranto
Pearson product-moment correlation coefficient, r	0.714*	0.845*	0.726*
	(n=44)	(n=22)	(n = 22)
Cronbach's alpha coefficient, ${f a}$	0.765^^	0.718^	0.784^^
	(n=252)	(n = 101)	(n=151)

**r*>0.70, ^a>0.70, ^^a>0.75

Additionally, the effect modification of regional affiliation on the relationship between maternal health variables and total CRISYS-R stressors was explored by regression modeling. A series of multivariable linear regression models was fitted such that total CRISYS-R stressors were predicted by: region, a maternal health variable of interest, and an interaction term. Models containing SF-12 variables showed statistical significance or nearsignificance of the interaction term (total score: p = 0.02; physical health sub-score: p = 0.08; and mental health sub-score: p = 0.02; all obtained via multivariable regression analysis), whereas the model of maternal PHQ-9 score did not have a significant effect modification term (p = 0.35 in the same analysis).

In univariate modeling of total CRISYS-R stressors by annual family income category, income was negatively associated with total stressors for the cohort as a whole (n = 136; medium vs. low: $\beta = -1.64$, p = 0.036; high vs. low: $\beta = -2.36$, p = 0.020; all obtained by ANOVA analysis). Sensitivity analyses of the Brescia and Taranto subgroups maintained the direction of association but were no longer statistically significant.

Meanwhile, univariate modeling of total CRISYS-R stressors by family net worth showed no significant correlation for the entire cohort or regional subgroups. Likewise, continuous variables of child age, child sex, maternal age, maternal education level, maternal occupation, paternal age, paternal education level, and paternal occupation were not significantly correlated with total CRISYS-R stressors.

Construct validity: multivariate modeling

Results of multivariate regression modeling, with total CRISYS-R stressors as the dependent variable, are contained in Tables 3 and 4. First, multivariate regression was performed from the variables shown to be statistically significant in the preceding analyses, as described in *Methods 2.4* (Table 3). To avoid redundancy from overlapping maternal mental health variables, four separate multivariate models were obtained. Each model included

Model (labeled by maternal health variable included)	Model A (Maternal PHQ-9 Score)	Model B (Maternal SF-12 Total Health Score)	Model C (Maternal SF-12 Physi- cal Health Sub-score)	Model D (Mater- nal SF-12 Mental Health Sub-score)
Maternal Health Variable: β (95% Cl), <i>p-value from linear regression</i>	0.18 (-0.04, 0.39), 0.11	-0.13 (-0.28, 0.01) <i>, 0.08</i> ^	-0.23 (-0.59, 0.13), 0.22	-0.18 (-0.38, 0.02), <i>0.08</i> ^
Region (Taranto vs. Brescia): β (95% Cl), <i>p-value</i>	1.62 (0.15, 3.09), 0.03*	1.51 (-0.01, 3.03) <i>, 0.05</i> ^	1.54 (0.00, 3.08) <i>, 0.05</i> ^	1.57 (0.06, 3.09), 0.04*
Annual Family Income (Low vs. Medium): β (95% Cl), <i>p-value</i>	-1.18 (-2.75, 0.38), 0.14	-1.09 (-2.74, 0.55), 0.20	-1.22 (-2.87, 0.44), 0.15	-1.16 (-2.79, 0.48), 0.17
Annual Family Income (Low vs. High): () (95% Cl), <i>p-value</i>	-1.82 (-3.92, 0.27), 0.09^	-1.91 (-4.04, 0.21), 0.08^	-2.01 (-4.15, 0.13), 0.07^	-1.97 (-4.09, 0.15), 0.07^
AIC	728.48	689.16	690.82	689.26

region, annual family income, and one of the four maternal health variables.

Although not statistically significant, worsened maternal health correlated with increased CRISYS-R stressors when controlling for region and family income in all four models (note that a high PHQ-9 score represents worsened maternal mental health whereas lower SF-12 scores represent worsened maternal health). Region was a significant or near-significant term in all models and annual family income (low vs. high) was nearly significant in all models. Models B, C, and D (in which SF-12 variables served as maternal health predictors) had comparable Akaike Information Criteria values, all substantially lower than that of Model A (in which maternal PHQ-9 score was an independent variable). The interaction term was not significant in any model and was therefore not included in final models.

Because several families did not provide information about annual income and some were missing information related to the SF-12 scores, these models are limited in sample size (n = 129 for Model A, n = 122 for Models B-D). Therefore, additional multivariate modeling was performed via stepwise selection (see Methods (2.4) to assess for a model that may better represent the full cohort (Table 4). Variables included in the resulting model (n = 198) were: region (Taranto vs. Brescia), maternal PHQ-9 score, and maternal SF-12 physical health score. In this model, the total number of reported stressors on CRISYS-R was significantly associated with: worsened maternal mental health (higher PHQ-9 Z-scores; β = 0.99, p = 0.001 by multivariable regression), worsened maternal physical health (lower SF-12 physical health Z-scores; β = -0.76, *p* = 0.009 by multivariable regression), and residence in Taranto rather than Brescia ($\beta = 1.26$, p = 0.02 by multivariable regression).

Discussion

This study validates an Italian-language version of the CRISYS-R questionnaire by demonstrating its statistical reliability, internal consistency, and construct validity in a diverse and representative sample of Italian-speaking families. Our cohort included 252 families residing in the heavily-industrialized areas of Brescia (Northern Italy; 40%) and Taranto (Southern Italy; 60%). Sociode-mographically, participating families were comparable to working- and middle- class communities across Europe [26].

Socioeconomic data suggested that many participating families risk financial insecurity and poverty. Of those disclosing financial information, 45% reported annual incomes under \notin 25,000. 42% of families did not know or declined to state their net worth, while 36% estimated a net worth below \notin 5,000. Consistent with national statistics, Southern Italian families reported significantly lower

Sciection			
Variable	Beta-coefficient	95% CI	<i>p</i> -value
Region (Taranto vs. Brescia)	1.26	0.19, 2.32	0.021*
Maternal PHQ-9 Score (Z-score)	0.99	0.40, 1.59	0.001**
Maternal SF-12 Physical Health Sub-score (Z-score)	-0.76	-1.33, -0.19	0.009**
Overall model			6.41×10 ⁻⁷ ****

Table 4 Multivariable regression of total reported stressors on the CRISYS in Family Systems-Revised survey, by stepwise variable selection

*p < 0.05, ** p < 0.01, ****p < 0.0001; CI = confidence interval; PHQ-9 = Patient Health Questionnaire-9; SF-12 = 12-Item Short Form Health Survey. All p-values were obtained by multivariable regression analysis

annual income and net worth than Northern Italian families. These self-reported data should be interpreted cautiously due to the risk of recall bias and because they do not adjust for family size or cost of living, which vary across Northern and Southern Italy.

Regarding maternal mental health, our study substantiates the high prevalence of depressive symptoms among working- and middle- class mothers, with 31% of mothers reporting clinical depression [27]. Uniquely, we demonstrate that maternal depressive symptoms directly correlated with the quantity of self-reported family life stressors encountered in a six-month timeframe.

Furthermore, our data align with previous CRISYS-R validations, including the Spanish-language validation by Berry and colleagues; [6, 7] the range and distribution of total family life stressors among our study's participants mirrored those of North American cohorts. This finding corroborates that stress perceptions obtained via the Italian CRISYS-R are reproducible. Statistically, the Italian CRISYS-R upheld the reliability and internal consistency conditions of validation.

The Italian-language CRISYS-R also demonstrated strong construct validity. In univariate analysis, the number of family life stressors inversely correlated with maternal mental and physical health, annual family income, and region (Brescia vs. Taranto). Controlling for region alone, each maternal health variable continued to be a significant predictor of total CRISYS-R stressors, indicating the centrality of maternal health variables to family life stress. Multivariate models where total CRI-SYS-R stressors were predicted by one maternal health variable, region, and annual family income showed that worsened maternal health, residing in Taranto (Southern Italy), and having low annual family income remained correlated with increased family life stress (although associations were not significant in all cases). Variables not hypothesized to correlate with family life stress (including child age, child sex, and parental age) were not associated with CRISYS-R outcomes, reinforcing the construct validity of the questionnaire.

Living in a region with higher levels of poverty and lower levels of institutional trust (Southern Italy) [28] is plausibly related to family life stress. Compared to Brescia participants, Taranto participants demonstrated an increased strength of correlation between life stressors and clinical measures of maternal health. Relatedly, it is well-known that pollution has outsized health impacts on disadvantaged communities relative to privileged communities. This study showed interregional disparities in family life stress and its relationship to maternal health across two highly polluted areas of differential social and economic privilege [14–18, 29]. Policymakers ought to consider these differences when distributing medical and public health resources amongst the Italian population.

The relationship between family stressors and poor maternal mental and physical health was also expected. Relationships between stress and poor health are complex because insults in one realm lessen resilience in the other realm, and promote unhealthy coping patterns that worsen both stress and health [30, 31]. Determining the directionality of this association was beyond the scope of this study but merits further investigation. Finally, literature shows that financial strain predisposes to chronic medical and psychiatric illness, while accelerating relationship conflicts and psychopathologies that undermine social support and healthy coping. Low-income families also experience stress due to exclusion from resources and opportunities [32, 33].

In another multivariate model, the variables of region, maternal PHQ-9 score, and maternal SF-12 physical health score predicted total CRISYS-R stressors. The multivariate model explained 13.7% of total variation in the quantity of family life stressors reported by mothers ($R^2 = 0.137$). Since CRISYS-R asks families about 60 distinct stressors, each dependent upon personal circumstances, substantial variation unexplained by measurable variables was expected. The adjusted R [2] value of our multivariate model demonstrates meaningful predictive value with only three dependent variables, despite inherent variability of the outcome; this highlights the importance of these three variables in relation to family life stress.

In regional sensitivity analysis, the magnitude of univariate associations between maternal health and family life stress was greater in Taranto (Southern Italy) than in Brescia (Northern Italy). This finding emerged despite similar sample sizes and distributions of PHQ-9 and SF-12 scores across regions. While correlations between maternal health and total incidents on CRISYS-R maintained statistical significance in the Taranto subgroup, only maternal PHQ-9 score remained significant in the Brescia subgroup. In Brescia, therefore, unmeasured factors may mediate the relationship between maternal health and family life stress.

Considering well-described healthcare inequities between Northern and Southern Italy, Brescia participants likely had higher-quality healthcare than Taranto participants. Given regional differences in social norms and family dynamics, Brescia mothers may have also benefited from greater gender parity and social recognition of their stressors [33, 34]. While these factors may not manifest statistically in a sample of this size, availability of such support is known to enhance health outcomes and coping skills in response to external stress [35, 36]. As such, unmeasured factors may have lessened the influence of Brescia mothers' health on their stress perceptions, or vice-versa. Such interregional differences are meaningful because they allow for the creation of public health interventions adapted to regional contexts of belonging [37]. Meanwhile, the interpretation of subjective questionnaires like CRISYS-R may also be influenced by regional linguistic and cultural differences [37, 38].

In multivariate analysis, maternal health variables more robustly predicted total CRISYS-R stressors than socioeconomic variables. Overall, study findings supported maternal health variables as more proximal metrics of family life stress than annual income or net worth, a conclusion aligned with current literature [39, 40]. Accordingly, public health strategies to improve family wellbeing might best measure success based on improvements in maternal health, rather than on strictly economic terms.

Considering the central role of maternal health variables in supporting the construct validity of the Italian CRISYS-R as a measure of family life stress, our study corroborates the notion that interventions supporting women's health – including increased social support for mothers and expansion of health services for low-income women– may have substantial positive impacts on stress perceptions at the household and community levels. These positive effects are often not captured in the formal impact measurement of women's health programs and merit dedicated attention.

Strengths and limitations

A major strength of this study is the representativeness of its sample population. Administering CRISYS-R across multiple regions adds methodological rigor by allowing for: increased external validity, greater insight into the impact of regional context on outcomes, more equitable representation of underserved populations in public health research, and interregional inclusivity in maternalchild health. Another strength is the study's health equity focus, derived from studying a vulnerable population of working-class mothers who face environmental stress owing to their proximity to industrial pollution sources. Regarding limitations, CRISYS-R outcomes besides total stressors were not analyzed due to gaps in data collection, and the study relied upon self-reporting modalities for data collection that may introduce bias.

Conclusions

The CRISYS-R questionnaire is a versatile tool with which to study the impact of family life stress on public health outcomes. This study validates a novel Italianlanguage version of CRISYS-R in a nationally representative study population. It describes the relationships of maternal health variables and household socioeconomic variables to family life stress, and provides evidence for interregional disparities in the frequency and health impacts of stress. This study has potential to inform public health policies and interventions serving families in Italian-speaking areas with high burdens of industrial pollution and may contribute to advancing health equity for communities facing simultaneous family life stress and environmental exposures. Future research should consider how stressors differentially affect marginalized communities. Furthermore, studies investigating the relationship between family life stress and the development of clinical pathologies may improve healthcare for populations in industrialized settings.

Abbreviations

CRISYS-R	Crisis in family systems-revised
ISEIA	Impact on health of exposure to environmental pollutants in the
	Brescia and Taranto areas
PHQ-9	Patient health questionnaire-9
SF-12	12-item short-form health survey
CI	Confidence interval
AIC	Akaike information criteria
SD	Standard deviation
IOR	Interguartile range

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Author contributions

D.P., M.Co., M.Me., A.G., and R.L. designed the study; D.P. supervised the study; G.C, C.F, A.P., M.Mo., D.B., and C.F. collected data. E.B. and S.R. analyzed the data. E.B. and A.P. drafted and revised the manuscript. E.B. prepared all tables. S.R., D.P., R.L., and Y.M.C. were major contributors to manuscript revision. All authors reviewed and approved the final manuscript.

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Data availability

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted according to the Declaration of Helsinki and was approved by the Institutional Review Boards of the Italian provinces of Brescia (NP2604; July 27, 2017) and Brindisi (N45/17; November 17, 2017). Written informed consent was obtained from all adult participants. For child participants (who were all under the age of 16), written informed consent was obtained from a parent or legal guardian and assent was obtained directly from participating children. Informed consent included permission to publish study findings and was obtained prior to study enrollment.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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