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A Microsimulation Model to Assess the Impact of Prevention Efforts to Combat Sex Trafficking out of Five Eastern European States

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Former Eastern bloc countries are major sources for sex trafficking. Estimates of the extent of trafficking out of these countries vary widely, and little knowledge exists on the effectiveness of anti-trafficking efforts. The objective of this work was to adapt microsimulation modeling to assess the impact of intervention efforts to combat sex trafficking out of Eastern Europe. We estimated trends of sex trafficking and compared interventions in terms of their reduction in sex trafficking. The overall incidence of sex trafficking out of Eastern Europe is projected to decrease, from about 140,000 women and children in 2007 to about 50,000 in 2017. However, the incidence rate increased in 2009 and 2012, consistent with the global recession. The most effective interventions are economic growth, followed closely by increased access to secondary education and restrictions on migration. Minimal reduction is achieved by raising awareness of the phenomenon and increasing TV usage. Yet, the primary mechanism currently being used to prevent sex trafficking out of Eastern Europe is public awareness campaigns. Efforts should focus more on boosting the economy, increasing access to secondary education, and facilitating dialogue about how to promote legal immigration avenues.

Keywords: Eastern Europe, microsimulation modeling, sex trafficking, stochastic modeling

INTRODUCTION

Human trafficking is the fastest growing criminal industry in the world and is the third largest, exceeded only by the drug trade and the illegal arms industry (Obuah, 2006). Although the numbers are disputable, according to the *Trafficking in Persons Report*, 27 million adults and children are in forced labor, bonded labor, and forced prostitution around the world at any given time (U.S. Department of State, 2012). Since the fall of the Iron Curtain, former Eastern bloc countries have

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become major source countries for trafficking of women and children. Estimates of the extent of trafficking in Eastern Europe vary widely. One report estimates that a minimum of 200,000 people from Eastern Europe and Central Asia have been trafficked (International Labour Office [ILO], 2005). Another report estimates from the United Nations Population Fund that more than 175,000 persons are trafficked annually in Europe and Central Asia (Mansoor & Quillin, 2006). The United Nations Office on Drugs and Crime (UNODC; 2006) report suggests that Eastern European trafficking victims are primarily young women who are exploited in the commercial sex industry.

Although there has been an increasing number of initiatives to respond to trafficking in persons (TIP), there is still relatively little knowledge of the effectiveness of these efforts since their impact has seldom been evaluated (U.S. Department of States, 2012). For example, are preventive efforts helping to decrease the number of victims of trafficking in persons? In fact, once an intervention is implemented and finished, despite the emphasis on generating sustainable outcomes, the monitoring and evaluation of these outcomes postproject often disappear (U.S. Department of State, 2012). However, the severity of the crime and the impact on its victims makes it of utmost importance to gain more insight into the effectiveness of anti-trafficking interventions. In order to establish a baseline to evaluate any progress in the implementation of such interventions, systematically collected knowledge on national, regional, and global patterns and trends is needed.

The objective of this work is to adapt microsimulation modeling, an evaluation method used for similar interventions in other areas such as health and welfare, to assess the impact of prevention and intervention efforts to combat sex trafficking to help build better knowledge-based policies. We developed a microsimulation model of sex trafficking out of five Eastern European states (Bulgaria, Belarus, Moldova, Romania, and Ukraine) to assess the past and future trends of sex trafficking out of these eastern European states and to compare interventions in terms of their reduction in sex trafficking.

This work addresses the gap in knowledge of the effectiveness of prevention and intervention efforts to reduce sex trafficking. By identifying the most effective interventions, we hope to guide countertrafficking policies and programs that lead to the ultimate goal of eliminating human trafficking. This new methodology will allow researchers, international agencies, and policy makers to move beyond a reliance on questionable statistics to assessing in more detail how well they are dealing with this problem.

METHODS

Data and Regression

Data to support the simulation model were obtained from GfK Ukraine. These data come from two unique cross-sectional household surveys that were commissioned by the International Organization for Migration (IOM) and cover five Eastern European countries. Fieldwork for the five-country survey was conducted in Belarus, Bulgaria, Moldova, Romania, and Ukraine in 2006 for the first survey (IOM, 2006) and 2008 for the second survey (IOM, 2008). The surveys cover both urban and rural areas and sampled households of all regions in the five countries. In total, 82 regions were surveyed. In both surveys, in each country, at least 1,000 individuals were interviewed, resulting in a total sample of over

5,000 households. The interviews were conducted with the person in the household having the most recent birthday.

Volosevych of GfK Ukraine provided additional information regarding the IOM surveys (personal communication, September 17, 2014). The household surveys were not piloted. Language barriers existed in both Moldova and Ukraine. To overcome these barriers, the survey conducted in Moldova was offered in both Romanian and Russian. Similarly, the survey conducted in Ukraine was offered in both Ukrainian and Russian. There were no language barriers in other countries. Regarding training of interviewers, in each country, the project manager organized a briefing for the field manager, the field manager organized a briefing for regional supervisors, and regional supervisors organized a briefing for interviewers. Administration of the survey took about two to three weeks per country. Participants were not compensated.

The data sets include standard characteristics like locality, household size, financial status, marital and employment status, education, and age of the interviewed person. In addition, people were asked about household migration experience and if they had heard of the phenomenon of human trafficking. Most importantly, interviewed persons were asked whether persons in their close surroundings (relatives, friends, and neighbors), in their close family, or they themselves had ever experienced situations that would be classified as trafficking. The term "close family" includes parents, children, husband/wife, brothers, and sisters of the interviewed person. The survey generally refers to households as identified by close family ties with respect to the interviewee and not by residency.

We performed a variation on a regression model by Mahmoud and Trebesch (2010) to inform our microsimulation. Mahmoud performed a rare event logit model, employing the same unique data set of households from Belarus, Bulgaria, Romania, Ukraine, and Moldova in 2006, to analyze the economics of human trafficking. Rare event logit regression involves computing the usual logistic regression maximum likelihood estimation and correcting the estimates based on prior information about the fraction of ones in the population and the observed fraction of ones in the sample (or sampling probability).

Mahmoud's dependent variable is an indicator denoting whether the interviewed person reported a victim of human trafficking among close family members. As the interviewee is by definition part of the close family, their dependent variable also includes the case when the interviewed person was a victim of human trafficking him- or herself. More specifically, the indicator takes the value of 1 if a close family member had traveled abroad and experienced one of the following situations: (a) "Was offered a domestic or nursing job, but was locked and forced to work for no pay," (b) "was offered a job at an enterprise, on a construction site, or in agriculture, but was locked and forced to work for no or little pay" or (c) "was offered employment, but the passport was taken away upon arrival to the destination country and was forced to work in the sex business."

Mahmoud used a set of individual, household, and regional variables. The individual variables include age, gender, level of education, and marital status of the respondent. On the household level, they used the number of children below the age of 17, an indicator for households living in rural areas, and an indicator for households living in the district around the capital city. To distinguish between households in Belarus, Bulgaria, Moldova, Romania, and Ukraine, they used a separate indicator for each state. To capture access to public information and news, they used an indicator for households with a television. It takes the value 1 if the respondent stated that he/she watched TV to get information on social and political issues. The regional variables include migration prevalence, awareness of trafficking, the fraction of the rural population, density of physicians, infant mortality, and crime rate. To capture "hot spots" of migration where individuals

had a significantly higher propensity to migrate compared to other regions, they used the migration prevalence ratio on the regional level. This variable is defined as the fraction of households in each region that reported having had a member of the close family abroad in the last 3 years. They also included a regional risk awareness measure, corresponding to the fraction of respondents in a region stating that they had heard of the phenomenon of human trafficking before. As a proxy for the rule of law and illegal activities on the regional level, they take the number of reported crimes per 10,000 inhabitants in the region, which they coded from the *Statistical Yearbooks* of each of the countries. Further regional control variables are included to account for the quality of public services, socioeconomic development, and remoteness. Concretely, they use the number of physicians per 10,000 inhabitants, the infant mortality rate per 1,000 live births, and the fraction of the population living in rural localities. These variables are also coded from the *Statistical Yearbooks* of each of the countries (Belarus, 2006, 2007, 2008, 2009, 2010; Bulgaria, 2006, 2007, 2008, 2009, 2010; Moldova, 2006, 2007, 2008, 2009, 2010; Romania, 2006, 2007, 2008, 2009, 2010; Ukraine, 2006, 2007, 2008, 2009, 2010).

There are two primary differences between Mahmoud's regression and our own. First, the focus of our study is on sex trafficking only as opposed to all forms of human trafficking. Therefore, our dependent variable is an indicator denoting whether the interviewed person reported a victim of sex trafficking among close family members. In particular, the indicator takes the value of one if a close family member had ever traveled abroad and experienced the following situation: "Was offered employment, but the passport was taken away upon arrival to the destination country and was forced to work in the sex business." Second, since a major objective of our study is to forecast future levels of sex trafficking, we added the gross domestic product (GDP) per capita, as a proxy for economic well-being, in which future forecasts are available. Since GDP is a linear combination of the indicator variables for each country, we removed the indicator variables for each country to prevent collinearity in the regression. The individual and household variables used in our regression are summarized in Table 1. The regional variables are summarized in Table 2.

TABLE 1
Individual and Household Variables and Their Definitions

Individual/Household Variables	*Definition*
Age (respondent)	Age of the respondent.
Male (respondent)	A dummy indicating whether the respondent is male or female.
No or Primary Education (respondent)	A dummy indicating whether the respondent's highest level of education is primary school or no education.
Secondary Education (respondent)	A dummy indicating whether the respondent's highest level of education is secondary school.
Married (respondent)	A dummy indicating whether the respondent is married.
Number of Children	The number of children (0–16 years) in the household.
Rural	A dummy indicating whether the household lives in a rural area.
Capital District	A dummy indicating whether the household lives in the district around their respective capital city.
TV Use	A dummy for households that use the TV, as opposed to other media and social contacts, to get informed about social and political issues.
GDP per capita	The gross domestic product per capita.

TABLE 2
Regional Variables and Their Definitions

Regional Variables	*Definition*
Migration Prevalence	The fraction of surveyed households in each region that reported to have had a member of the close family abroad in the last three years.
Awareness of Trafficking	The fraction of respondents in each region who stated that they had heard of the phenomenon of human trafficking before.
Fraction of Rural Population	The fraction of people in each region living in rural localities.
Density of Physicians	Regional density of physicians per 10,000 inhabitants.
Infant Mortality	Regional infant mortality rates per 1,000 live births.
Crime Rate	The level of criminal activity (reported crimes per 10,000 inhabitants in a region).

The regression was performed on the 2006 data set using ReLogit (King & Zeng, 2001), a suite of programs for estimating and interpreting logit results when the sample is unbalanced (one outcome is rarer than the other) or has been selected by a rule correlated with the dependent variable. The program is designed for use with the Stata statistics package.

Microsimulation Model

The use of a microsimulation model is necessary to assess the risk of sex trafficking on an individual in a population, given their own characteristics as well as those of their household, region, and country. In a microsimulation model, individual life histories are simulated and the timing of events are determined stochastically. In contrast, a group-based model moves groups of individuals through stages based on transition probabilities.

Our microsimulation model simulates a population of households longitudinally through time and tracks whether the primary respondent or someone in their close family has ever experienced a situation that would be classified as sex trafficking. The 2006 IOM human-trafficking survey is taken as the starting population and provides individual, household, and regional characteristics. The microsimulation begins with 10 million simulated households entering the model in 2006. The households are followed for 12 years (2006 to 2017). This time horizon was chosen based on the availability of data to 2017 in statistical yearbooks. The household population is dynamic, with a continual process of aging and family members dying and being born. Primary respondents who die are randomly replaced by another member in the household. As the household ages, individual, household, and regional variables are updated. The regression coefficients are applied annually to the characteristics of each household to estimate the respondent's probability of reporting a victim of sex trafficking among close family members. Pseudocode of the model structure is provided in the appendix. The microsimulation model was implemented in the C++ programming language (Law & Kelton, 2000; Matsumoto & Nishimura, 1998). The methodology for updating individual, household, and regional characteristics is described here.

Ages of household members

A limitation of these data is that the ages of household members other than the respondent are not provided. Therefore, we must infer the ages of other household members based on information provided. The survey provides the respondent's age, gender, marital status, rural/urban status, and education level. The survey also provides the number of people in the household and the number of children in the household. The number of adults is calculated by subtracting the number of children in the household from the number of people in the household.

Our approach to determine the ages of the other household members is done in two parts. We use information on both age structure as a function of family size and age structure of the population. According to a study by Csáki and Lerman (1997), which summarizes the first five years (1991–1996) of agrarian reforms in Ukraine, the age structure of families as a function of family size is given in Table 3. According to Table 3, as families become larger, the proportion of young persons under 18 increases. In families of four or more, children and youth represent over 35% of family members. The proportion of seniors is relatively high only in small families of one or two. In larger families, the proportion of seniors is around 5%, increasing to 13% in families of size six or more. As a result of these trends, and mainly due to the increasing proportion of children and youngsters in large families, the dependency ratio rises steeply from 0.37 in families of three to 1.0 in families of six or more. While this age structure is specific to rural farm-employee families in Ukraine, it is applied to both rural and urban households in all five countries of interest due to a lack of similar data in other countries.

Since the survey provides the number of children in a household, Table 3 is used to determine the number of adults and seniors in a household. To infer exact ages, we employ population pyramids by country and gender (U.S. Census Bureau, n.d.b). We assume family structure (who lives with whom) remains constant over time.

Gender of household members

The gender of household members is based on data from the U.N. Statistics Division (2008c) and is conditional on age and urban/rural status (population by age, sex, and urban/rural residence: latest available years, 1997–2006).

TABLE 3
Age Structure as a Function of Family Size (Percent of Family Members)

Family Size	*Adults (18–60)*	*Seniors (60 and Older)*	*Children and Youth (Under 18)*	*Dependency Ratio*
1–2	66	29	5	–
3	73	5	22	0.37
4	61	3	36	0.64
5	56	7	37	0.79
6 and more	50	13	37	1

Survival status of each family member

As each family member ages, he/she faces age-, sex-, and urban/rural-specific mortality hazards. Mortality hazards are based on data from the U.N. Statistics Division (2008a; death rates specific for age, sex, and urban/rural residence: latest available years, 1997–2006) . We assume death rates remain constant over time.

New respondent's characteristics

If a respondent dies, he/she is randomly replaced by another member of the household (adult or senior). The new respondent's characteristics (marital status and education level) must be determined. The new respondent's marital status is based on data from the U.N. Statistics Division (2006) and is conditional on age, sex, and urban/rural status (population by marital status, age, sex, and urban/rural residence: each census, 1985–2004). The new respondent's educational attainment comes from multiple sources. For Romania and Bulgaria, educational attainment is based on data from the U.N. Statistics Division (2007; population by educational attainment, age, sex, and urban/rural residence) and is conditional on gender, age, and urban/rural status. For Ukraine, Moldova, and Belarus, school attainment is based on data from the World Bank's (2005) Household Survey Education Profile and is also conditional on gender, age, and urban/rural status.

Number of children/adults in the household

As members of the household age, the number of children and the number of adults in a household will vary depending upon births, deaths, and children (less than 17 years) becoming adults. Therefore, the number of children and the number of adults in the household must be tracked and updated annually. Live-birth rates are based on data from the U.N. Statistics Division (2008b) and are conditional on age of mother and urban/rural status (live-birth rates specific for age of mother, by urban/rural residence: 1990–1998). We assume live-birth rates remain constant over time.

Characteristics dependent on survey data

To estimate variables that depend on survey data (TV use, capital district, human-trafficking awareness, migration prevalence) beyond 2008, we compare the fraction in the 2006 IOM human- trafficking survey to the fraction in the 2008 IOM human-trafficking survey. We fit a linear least-squares regression equation to the data and extrapolate to make predictions outside the 2006–2008 range. The margin of error at 95% confidence is calculated as the following:

$$margin = 1.96 * \sqrt{\frac{f * (1 - f)}{n}},$$

where f is the fraction and n is the sample size. From the equation of the line, we can estimate the fraction of households that share a characteristic in future years. Using the example of TV use, if the number of households that use TV in future years increases, then we assign TV use to randomly

selected households that do not use TV. Similarly, if the number of households that use TV in future years decreases, then we remove TV use from randomly selected households that use TV. If the extrapolation yields a fraction greater than 1, we use 1. Similarly, if the extrapolation yields a fraction less than 0, we use 0.

Given the lack of data for previous years, there is no way to check that the relationship between the fraction of households that share a characteristic versus year is linear. Consequently, the more removed the prediction is from the range of values used to fit the model, the riskier the prediction. This limits our ability to forecast future levels of trafficking.

Characteristics independent of survey data

To evaluate trends in characteristics that do not depend on survey data (share of rural population, infant mortality, density of physicians, crime rate), we refer to the *Statistical Yearbooks* of the respective countries.

Gross Domestic Product

We added an additional variable, as a proxy for economic well-being, in which future forecasts are available: GDP per capita. GDP per capita, by country, for past and future years is provided by the International Monetary Fund (n.d.). GDP is calculated up to 2010 and estimated for subsequent years to 2017.

Family dissolution

There are two situations in which a household dissolves. The first situation occurs when all members of a household die. The second situation occurs when all adults and seniors in the household die, leaving only children. When either of these situations occur, the household is no longer tracked. To prevent effects of attrition on microsimulation outcomes, we replaced dissolved households with households from the 2008 IOM survey.

Outcomes

The primary outcomes are the one-year incidence in households reporting a close family member who has experienced sex trafficking and the number of new people who report having a close family member who has experienced sex trafficking. The one-year incidence is calculated by (a) taking the difference in the number of households that reported a close family member at some point in their lifetime had experienced sex trafficking in consecutive years and (b) dividing by the number of households that did not report that a close family member at some point in their lifetime had experienced sex trafficking. To ensure that a household that reports a case of sex trafficking in a given year reports that same case in subsequent years, we automatically count that case in subsequent years.

The number of new people that suffered from sex trafficking was calculated as a share of extended families who suffered from the situation multiplied by the country's population divided by the average size of an extended family. The population of each country by year

was taken from the *CIA World Factbook* (U.S. Census Bureau, n.d.a) and the average size of the family was estimated from the microsimulation.

Sensitivity Analyses

We performed two sensitivity analyses by quantifying changes in the one-year incidence rate of sex trafficking as we varied the regression coefficients simultaneously by (a) a maximum of ±10% and (b) a maximum of ±20%. For each analysis, we generated 500 sets of coefficients corresponding to random numbers within the lower and upper bounds defined above. We ran a simulation for each of these 500 sets of coefficients for both analyses.

Validation

We applied the International Society for Pharmacoeconomics and Outcomes Research–Society for Medical Decision Making (ISPOR-SMDM) criteria for model validation (Eddy et al., 2012). Verification or internal testing was performed to ensure that there were no unintentional computational errors. This was achieved using multiple techniques: maintaining complete and up-to-date documentation of the code, sensitivity analysis, extreme value analysis, trace analysis in which individual events and their timing are tracked, and verification of separate parts of the model one by one. While we recognize the need for an external validation, no such data exist for which the model can be externally validated. Only Germany and the Netherlands are currently able to provide official statistics on trends in trafficking over several years, making it difficult to accurately establish the extent to which trafficking is changing elsewhere (Laczko, 2005). Therefore, we substantiate the model's results with statements made by credible sources.

Interventions

To estimate the impact of various interventions for combating sex trafficking in Eastern Europe, we used the microsimulation model to explore a range of "what if" scenarios about the outcomes of policy reforms. The interventions were implemented by manipulating a variable of interest, while holding other variables constant, and observing change to the outcome. We examined five "what if" scenarios: (a) What if there was complete awareness of the phenomenon of sex trafficking? This was implemented by assigning awareness to households that reported no awareness. (b) What if all households used TV to get informed about social and political issues? This was implemented by assigning TV use to households that reported no TV use. (c) What if at least one person in every household had a secondary education? This was implemented by assigning a secondary education to all respondents who reported no education or primary education as their highest educational attainment. (d) What if all the "hot spots" of migration were eliminated? This was implemented by assigning no migration to households that reported to have had a member of the close family abroad in the last 3 years. (e) What if there was more economic growth than the present? This was implemented by increasing GDP per capita estimates by 10%.

TABLE 4
Results of the Rare Event Logit Regression

	Coef	SE
Migration Prevalence	1.960***	0.732
Awareness of Trafficking	−0.797	1.813
TV Use	−1.278***	0.168
Number of Children (0–16 years)	−0.003	0.207
Rural	−0.221	0.460
Capital District	1.953***	0.497
Share of Rural Population	−0.651	0.654
Infant Mortality	0.091***	0.021
Density of Physicians	−0.006	0.020
Crime Rate	−0.018*	0.011
Age (respondent)	−0.018	0.015
Male (respondent)	0.571***	0.186
No or Primary Education (respondent)	0.690	0.543
Secondary Education (respondent)	0.344	0.485
Married (respondent)	1.011	0.864
GDP per capita	−0.225***	0.066
Constant	−3.947**	1.744

Note. *** $p < 0.01$; ** $p < 0.05$; *$p < 0.1$.

RESULTS

Regression

Table 4 summarizes the results of our regression. First, we find migration prevalence, TV use, households living in the district around the capital, and GDP per capita to be the key predictors of sex trafficking. The incidence of sex trafficking appears to be higher in households that live in regions of higher migration prevalence, in households that live in the district around the capital, in households that do not use the TV, as opposed to other media and social contacts, to get informed about social and political issues, and in countries with lower GDP per capita. There is also evidence that households in regions with higher infant mortality rates are more likely to report a sex-trafficked member.

Sex-Trafficking Trends

Using the microsimulation model, past patterns and future trends of sex trafficking out of Eastern Europe were estimated, including increases and decreases during certain periods. It is important to clarify that these sex-trafficking trends are from the microsimulation model and are not the results of a survey. Figure 1 shows the one-year incidence rate of households with experience with sex trafficking (per 1,000) out of Eastern Europe predicted by the model from 2007 to 2017. Figure 2 presents the same incidence trend in terms of the number of individuals with direct or indirect experience with sex trafficking. The overall trend of sex trafficking has been decreasing from about 140,000 women and children (4.6 per 1,000) in 2007 to about 50,000 women and children (1.5 per 1,000) in 2017. However, the incidence rate increases at two separate instances (in 2009 and 2012).

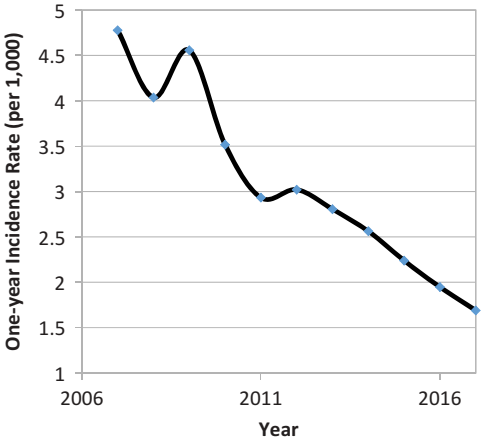

FIGURE 1 Overall 1-year incidence (per 1,000) of households who have experienced sex trafficking as predicted by the microsimulation model for five Eastern European countries.

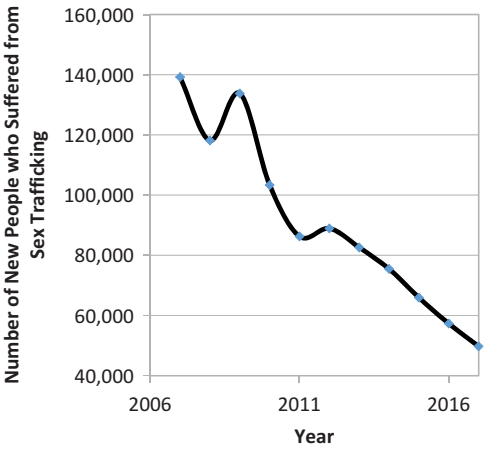

FIGURE 2 Number of new people who report a family member having had experience with sex trafficking as predicted by the microsimulation model for five Eastern European countries.

Sensitivity Analyses

Because of uncertainty in our regression coefficients, we varied the regression coefficients simultaneously by a maximum of ±10% and ±20% to evaluate the effect on the one-year incidence of sex trafficking. Figures 3 and 4 show the results of the sensitivity analyses on the regression coefficients. The solid curve is the one-year incidence rate (per 1,000) of sex

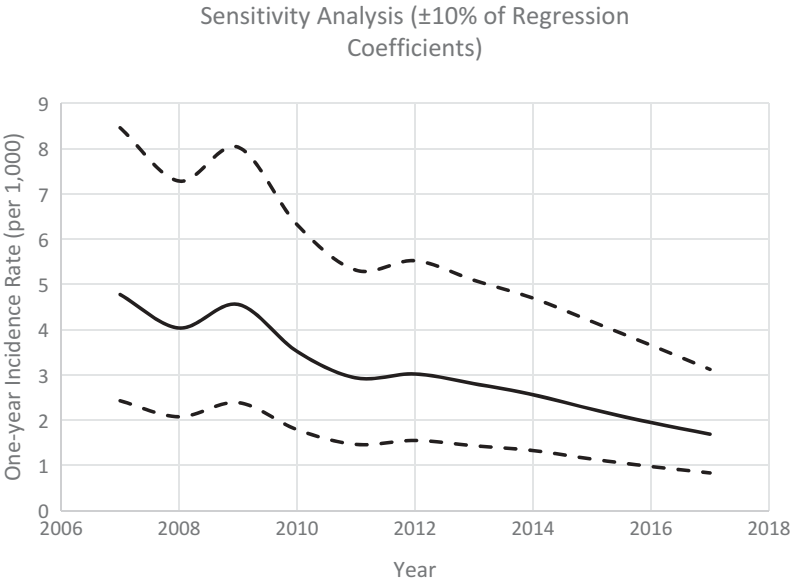

FIGURE 3 Sensitivity analysis corresponding to ±10% on the regression coefficients. The solid curve is the one-year incidence rate (per 1,000) of sex trafficking corresponding to the actual regression coefficients; the two dashed curves are the 1-year incidence rates (per 1,000) of sex trafficking corresponding to the sets of coefficients producing the lower and upper bounds. The other 500 curves (not shown) fall between the lower and upper bounds.

trafficking corresponding to the actual regression coefficients; the two dashed curves are the one-year incidence rates (per 1,000) of sex trafficking corresponding to the sets of coefficients producing the lower and upper bounds. The other 500 curves fall between the two dashed lines. In this analysis, the upper and lower bounds follow the same trend as the curve corresponding to the actual regression coefficients.

Validation

Our microsimulation model projects an overall decrease in the one-year incidence of sex trafficking out of Eastern Europe during the time interval 2007 to 2017. Our finding is consistent with statements made by the UNODC (2009). The UNODC reports that traditional human-trafficking flows to Europe, such as those originating from the Ukraine, have decreased sharply as of late. Romanian and Bulgarian victims, although still detected in large quantities in many countries, registered a decreasing trend in some European countries in the last few years. The UNODC also reports that in Germany, the presence of victims from Belarus and Ukraine has drastically reduced in the last few years. Similarly, in the Netherlands, the identification of Ukrainian victims registered a peak at the beginning of this decade to decrease basically to zero in recent years. Also, although still significant, trafficking from Bulgaria and Romania to the Netherlands has slightly decreased in recent years. In

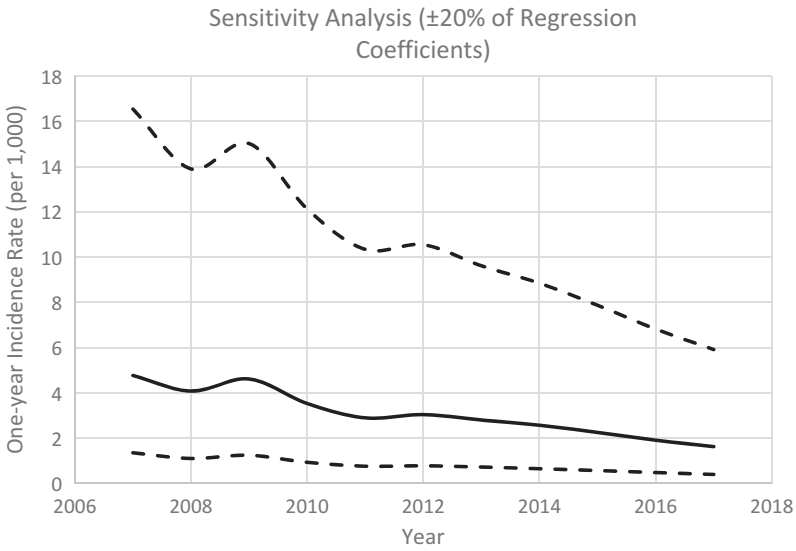

FIGURE 4 Sensitivity analysis corresponding to ±20% on the regression coefficients. The solid curve is the one-year incidence rate (per 1,000) of sex trafficking corresponding to the actual regression coefficients; the two dashed curves are the one-year incidence rates (per 1,000) of sex trafficking corresponding to the sets of coefficients producing the lower and upper bounds. The other 500 curves (not shown) fall between the lower and upper bounds.

Kosovo, the number of Ukrainian victims also decreased, together with a sharp decrease in victims from Moldova and Romania. In Turkey, the share of victims from Ukraine has decreased to 4–5%. Similar trends have also been recorded in Greece and Italy.

Our microsimulation model also shows a rise in sex-trafficking incidence in both 2009 and 2012, consistent with the global recession. As illustrated in Figure 5, the rise in 2009 coincides with a drop in GDP per capita in all five eastern European countries. The rise in 2012 coincides with a drop in GDP per capita in Belarus and Bulgaria. According to a U.S. Department of State report (2009), a global economic crisis boosts the demand for human trafficking because of a growing demand for cheap goods and services. Increasing poverty, reduced budgets for social services, and restrictive immigration laws drive more vulnerable children and young people to be exploited by the global sex trade.

Interventions

Figure 6 shows the one-year incidence rate of sex trafficking out of Eastern Europe in 2017 for each intervention and the status quo (no intervention). The intervention producing the greatest reduction in one-year incidence of sex trafficking out of Eastern Europe is economic growth, followed closely by increased access to secondary education and restricted migration. In comparison, minimal reduction is achieved by raising awareness of the phenomenon of sex trafficking and increasing TV usage to get informed about social and political issues.

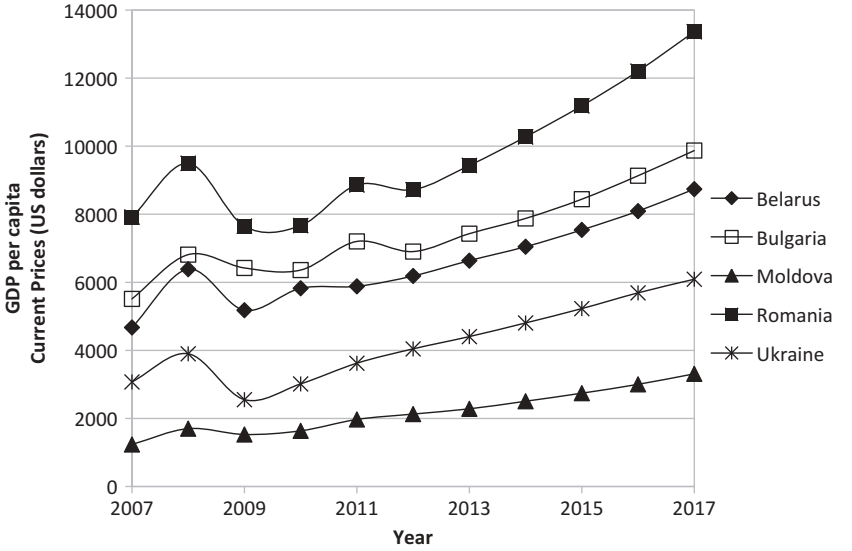

FIGURE 5 GDP per capita in current prices (U.S. dollars) versus year by country.

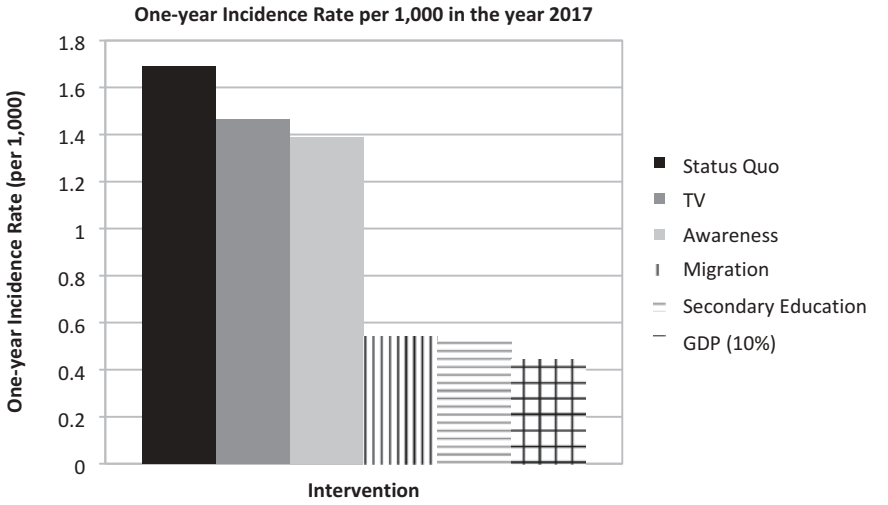

FIGURE 6 The one-year incidence rate of sex trafficking out of Eastern Europe in 2017 for intervention and no intervention (labeled "status quo").

DISCUSSION

Sex-Trafficking Trends

While the overall trend of sex trafficking appears to be decreasing, it is important to understand the correlation between sex trafficking and the economy and the unpredictability and volatility of the global economy. A recent report from Bill Gross's Pacific Investment Management Company, LLC (PIMCO) is forecasting a 60% chance of another global recession in the next three to five years (Petroff, 2013).

While our model suggests that the number of sex-trafficking victims may be in decline, there is another hypothesis that the number is increasing and has become more hidden and better organized (Limanowska, 2005). Limanowska explains that the people supporting this position are those with considerable experience in working on trafficking in the region. They have a good understanding of the situation, good contacts, and access to information not available to the general public. Instead of finding trafficked women in bars and brothels, traffickers are bringing women into the private domain. This includes working out of apartments or by the Internet and phone. Limanowska further writes that it is likely that the reality is a combination of these two possibilities: Anti-trafficking measures are effective to some extent and trafficking has been pushed deeper underground and more hidden.

Sensitivity Analyses

While there is uncertainty in our regression coefficients, the past and future trends of sex trafficking out of Eastern Europe remains the same — an overall decrease with rises in 2009 and 2012.

Interventions

Our work suggests that the most effective interventions in reducing sex trafficking out of Eastern Europe are economic growth, followed closely by an increase in access to secondary education and restricted migration. Minimal reduction is achieved by raising awareness of the phenomenon of sex trafficking and increasing TV usage to get informed about social and political issues. Efforts should focus less on raising awareness through campaigns and TV usage and more on boosting the economy, increasing access to secondary education, and facilitating sincere dialogue about how to promote legal immigration avenues and regulations. Yet, the primary mechanism currently being used to prevent sex trafficking out of Eastern Europe is public awareness campaigns. The Government of Belarus conducted public awareness campaigns on radio, in print, and on television (U.S. Department of State, 2012). The Government of Bulgaria sponsored a number of innovative public awareness-raising campaigns to attempt to reduce the demand for sex trafficking and to reach vulnerable groups looking for summer jobs abroad (U.S. Department of State, 2012). The government of Moldova organized 30 seminars in high schools and universities for over 2,000 students on preventing and combating human trafficking. Moldova also conducted a weeklong campaign with awareness-raising activities including a screening of a film based on testimonies of victims of trafficking and domestic violence (U.S. Department of State,

2012). The Government of Romania implemented six national and regional public awareness campaigns and 36 local campaigns in 2012. These campaigns were visible in primary schools, high schools, bus advertisements, televisions, in metro stations, movie theaters, and on the Internet (U.S. Department of State, 2012). The Government of Ukraine conducted an anti-trafficking information campaign to raise awareness about all forms of trafficking reaching approximately 2.3 million people (U.S. Department of State, 2012).

One possible explanation for the minimal effect of raising awareness of the phenomenon of human trafficking and increasing TV usage is that the Eastern European population thought to be at risk for sex trafficking has been saturated with knowledge about the risks of sex trafficking by nongovernmental organizations, government agencies, and UN programs. But the push factors, such as poverty, unemployment, and discrimination, are so strong that people are willing to accept risky offers. It could be more complicated than simply a lack of knowledge.

This work supports increasing access to secondary education. One example of a promising program to prevent the trafficking of girls and women for sexual and labor exploitation in Cambodia is called "Girls Be Ambitious." The program supplies an incentive for girls from indigent homes to stay in school and to receive additional vocational training that will provide employment alternatives, income generation, and social and political empowerment. The incentive for girls and their families to attend school is in the form of financial assistance of US$10 a month for girls with a "perfect" attendance rate. If the girl does not have perfect attendance, she will not be paid that month.

This work also supports the need for a sincere dialogue about how to promote legal immigration avenues and regulations based on a credible assessment of the labor requirements and migration policies of each country.

Limitations

One limitation of the model reflects the level of analysis of the data used to inform the model. The IOM surveys are household survey data and therefore the decision-making microunit is the household as opposed to the individual. The issue with this is the inability to model interventions at the level of the individual. For example, one intervention focused on increasing access to secondary education. Since data are not available for each person within a household, we could not model the effect of educating females in a household. Instead, we modeled the effect of educating at least one person in every household (the respondent, male or female).

A second limitation is the limited data available to inform the model. As noted previously, to estimate variables that depend on survey data (TV use, capital district, human-trafficking awareness, migration prevalence) beyond 2008, we fit a linear least squares regression equation to two data points. The quality of this extrapolation is limited by the assumption that the trend is linear. If the trend is nonlinear, then a linear fit will be poorly extrapolated. A further data limitation is that the survey included the responses of only one person within a household. It is possible that the respondent withheld the truth due to being afraid of stigmatization or problems with the authorities at home or abroad. It is also possible that the respondent did not answer the questions correctly due to forgetfulness caused by dementia or memory lapses.

A third limitation was the inability to perform a quantitative external validation of the model. A quantitative external validation would evaluate how well the microsimulation model reproduces

the observed incidence of sex trafficking at some later point in time. But currently, the amount of data collected on sex trafficking is limited, thereby making it impossible to validate the model.

A further limitation is the absence of a cost-effectiveness analysis to determine the value that interventions will deliver. More research is needed to incorporate this aspect into the microsimulation model.

Further Analyses

There are a magnitude of consequences of sex trafficking for which the microsimulation model can act as a substrate on which further analyses can be performed. HIV infection is among the most significant potential health consequences and is the one for which the best data are available. Hence, it makes sense from both a modeling and response perspective to focus on HIV when assessing the health consequences of sex trafficking. Additionally, from a health perspective, victims face serious physical internal injuries such as head injuries and broken bones, sexually transmitted diseases, tuberculosis, permanent damage to reproductive systems, and posttraumatic stress disorder. Sex trafficking also has widespread negative nonhealth consequences for individuals and societies. For example, sex trafficking helps to promote societal breakdown by removing women and girls from their families and communities. If and when victims are able to return to their communities, they often find themselves doubly victimized by social stigmatization, discrimination, and rejection. Sex trafficking also fuels organized crime groups that usually participate in many other illegal activities, including drug and weapons trafficking and money laundering. In addition, sex trafficking negatively impacts local and national labor markets, due to the loss of human resources. The effects include depressed wages, fewer individuals left to care for elderly persons, and an undereducated generation. Sex trafficking also erodes government authority, encourages widespread corruption and threatens the security of vulnerable populations.

The way in which to incorporate a health consequence into the model will vary depending upon the available data and how these data link that particular health consequence to predictors used in this model. For example, let's consider HIV infection. HIV can be incorporated into the model by using data that link HIV and predictors used in this model among rescued sex-trafficked women and girls in Eastern Europe. Just as we assessed the impact of intervention efforts to combat sex trafficking, we can assess the impact of these interventions, as well as interventions tailored to reduce HIV infection, on HIV infection among sex-trafficking victims. For example, we could answer questions, such as "what is the reduction of the incidence of HIV infection among sex-trafficked victims if there was complete awareness of the phenomenon of sex trafficking?"

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Appendix: Pseudocode of Model Structure

For each household:

Step 1: Assign baseline characteristics based on 2006 IOM survey.
Step 2: Determine the ages of the other household members.
Step 3: Determine the gender of the other household members.
Step 4: Determine whether the respondent reports a victim of sex trafficking among close family members.

For each year and each household:

Step 5: Determine whether each household member survives another year.
Step 6: If the respondent does not survive, replace respondent and determine new respondent's characteristics.
Step 7: Increment the ages of each household member that survives.
Step 8: Determine whether there is a new birth in the household.
Step 9: Update the number of children and the number of adults in the household.
Step 10: Update household variables.
Step 11: Update regional variables.
Step 12: Determine whether the respondent reports a victim of sex trafficking among close family members.