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EVIDENCE OF DIFFUSION FROM A TARGETED HIV/AIDS INTERVENTION IN THE DOMINICAN REPUBLIC

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Summary. The diffusion potential of a targeted HIV/AIDS intervention that enlisted peer educators to disseminate 'safer sex' messages and condoms among female commercial sex workers and their clients was evaluated in the Dominican Republic. Levels of interurban interaction potential were ascertained that linked the targeted city of La Romana with the proximate cities of San Pedro de Macoris and Guaymate. Weekly service statistics generated over an 8-month period were analysed to establish activity areas for the peer educators. Data were entered and analysed using a geographic information system and interurban linkages were established. Project outcomes were examined via a series of three cross-sectional Knowledge, Attitudes and Practices (KAP) surveys conducted among convenience samples of commercial sex workers at the start of the intervention and at 4 and 8 months. The results attest to a high degree of interconnectivity between the targeted and proximate cities, and a pattern of interurban mobility that links commercial sex workers, clients and establishments in all three cities. The examination of project outcomes revealed statistically significant changes in condom use in the targeted city of La Romana among commercial sex workers, as well as among their counterparts interviewed in the proximate cities of San Pedro de Macoris and Guaymate. These data suggest a diffusion effect. It is concluded that a targeted intervention may influence proximate cities within a relatively compressed period of time. The findings suggest the importance of considering geographic diffusion principles, such as urban hierarchies, regional nodes and transportation linkages, when designing HIV/AIDS prevention efforts. It also has important implications in the selection of control sites when conducting experimental studies of HIV/AIDS interventions.

Introduction

Targeted interventions directed at individuals who engage in high-risk sexual behaviour are an important strategy in national HIV/AIDS prevention programmes. Targeted interventions are an established public health intervention strategy (Walsh & Warren, 1979), and have been shown to be a cost-effective approach for controlling HIV/AIDS and other sexually transmitted diseases (STDs) (Ngugi & Plummer, 1988; Ngugi *et al*., 1988; Over & Piot, 1990; Moses *et al*., 1991; Plummer *et al*., 1991; Ngugi *et al*., 1996).

The rationale for targeted programmes is clear. Individuals who have multiple sex partners, such as commercial sex workers (CSWs) or their clients, are at higher risk of contracting and re-transmitting sexually transmitted infections, such as HIV, than members of the general population. Targeting such 'vulnerable groups', therefore, through behaviour change, education and condom distribution interventions makes good sense programmatically (Potts & Feldblum, 1990; Centers for Disease Control and Prevention, 1988; Plummer *et al*., 1991; Thomas & Tucket, 1996; Potts, Anderson & Boily, 1991).

Numerous evaluations of AIDS interventions have demonstrated an effect at the level of the targeted community, with the desired increases in knowledge, changes in attitude and reported increases in condom usage and appropriate health-seeking behaviours (Moses *et al*., 1991; Wilson *et al*., 1990; Suarez *et al*., 1990; Asamoah-Adu *et al*., 1994; Ngugi *et al*., 1996). While encouraging, such data raise questions about the limitations of a programme that produces only a localized effect in the face of the enormous challenge posed by escalating HIV prevalence in many parts of the world. To date, no effort has been made to track the diffusion of the educational message and measure programme outcome beyond the targeted community itself.

This paper focuses on the peer education model, an approach that is widely cited as an important tool in the armament of HIV/AIDS control strategies. Peer education has been effective in conveying and disseminating health-related information, and serves as a credible model for behaviour change interventions (Fredericksen, Solomon & Brehony, 1984; Kelly *et al*., 1991; Ngugi *et al*., 1996). These programmes function within informal peer networks and have proved to be effective in disseminating and promoting HIV risk reduction among marginalized target groups, such as CSWs and their clients (Kelly *et al*., 1991, Ngugi *et al*., 1996), and are an important approach in community-based efforts to limit the spread of HIV in the developing world.

An important premise behind such peer educator-based AIDS prevention programmes is that the 'safer sex' message diffuses through the community at increased risk, e.g. that of CSWs and their clients. Everett Rodgers lists four main elements in any diffusion event: an innovation, i.e. an idea perceived as new by the potential adopting unit, the channel of communication, the social system in which the diffusion occurs, and time (Rogers, 1971, 1979). An innovation, such as safer sex, communicated through peer education channels, within a social network of commercial sex workers over time is an appropriate application of Rogers' basic theoretical framework to a peer education-based HIV/AIDS prevention programme.

If there is a spatial element in the diffusion process, as some social scientists have demonstrated (Hagerstrand, 1967; Brown, 1975; Brown, Malecki & Spector, 1976),

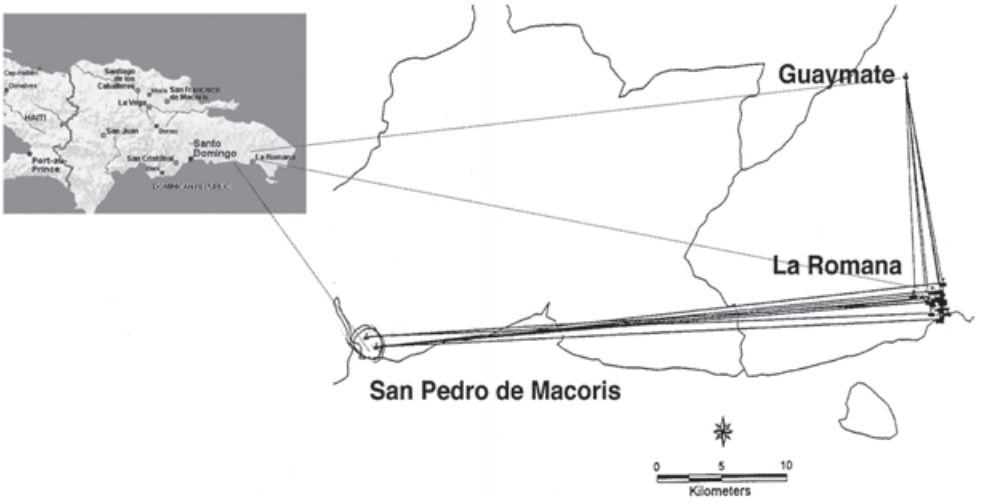

Fig 1. Interurban mobility patterns linking peer educators and commercial sex establishments in the Dominican Republic study area. The continuous lines represent frequency of individual peer educator interurban mobility by T_3.

the messages delivered via a targeted intervention should be detectable in neighbouring communities. Yet, the empirical evidence for this diffusion effect has been lacking in the HIV/AIDS prevention literature.

This paper reports on an effort to define the diffusion potential of a peer education-based HIV/AIDS prevention programme in the Dominican Republic. The intervention was implemented in the city of La Romana. It consisted of peer educator recruitment and training and an education campaign based on increasing condom use among the targeted population of CSWs. Peer educator mobility was assessed and evidence of programme outcome sought in the targeted city of La Romana and in two proximate cities of varying sizes and distances from La Romana – San Pedro de Macoris and Guaymate – using a series of Knowledge, Attitudes and Practices (KAP) surveys (Fig. 1)

Methods

Volunteer peer educators were recruited by word of mouth within the community of sex workers in La Romana. All CSWs recruited into the project received a standardized training programme that emphasized risk-reduction strategies, including the regular and consistent use of condoms. No effort was made to influence their mobility, nor were financial incentives provided to encourage interurban travel. Peer educators travelled to commercial sex establishments within La Romana and the other two cities included in the study based on their own interests.

A census of commercial sex establishments (CSEs) in each community was conducted prior to the initiation of the study. Commercial sex establishments were defined as locations in which commercial sex is transacted, i.e. bars or brothels. Each

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CSE was located on a base map for each city in the study and later digitized and incorporated into a Geographic Information System (GIS) database. A total of 45 CSEs were identified in La Romana, 32 CSEs were identified in San Pedro de Macoris and nine CSEs were identified in Guaymate.

Regular contact was maintained with the peer educators throughout the project. Service statistics were collected to obtain the number of peer educators active in the project during the time period in question, and their geographic range of activities. Each week, data were gathered on peer educators' activity and mobility patterns around a set of commercial sex establishments (CSEs) in La Romana, San Pedro de Macoris and Guaymate. Each peer educator was given a unique three-digit identifying code, which permitted the linking of peer educator activity with CSEs in the three cities.

The GIS database was established using the Mapping Information Systems product, MapInfo for Windows, version 5·0 (MapInfo Corp., 1993). The GIS included the location of CSEs, and peer educator activity by week in the identified CSEs. A vector map was constructed connecting all CSEs associated with a particular peer educator, permitting a cartographic assessment of diffusion-enhancing peer educator mobility.

Diffusion pathways and interurban connectivity

The gravity model was employed to estimate the relative interaction potential of each location using the gravity model (Meade, Florin & Gesler, 1988). The gravity model estimates the relative strength of each location in terms of interaction potential using the following equation:

$$I_a = \frac{P_a \times P_a}{1} + \frac{P_a \times P_b}{D_b^2} + \cdots \frac{P_a \times P_n}{D_n^2}.$$

The term I_a represents the interaction potential of the targeted city of La Romana, which is a function of its population size and the distance between the proximate cities. The terms P_a, P_b and P_n represent the population sizes of La Romana, San Pedro de Macoris and Guaymate, respectively. The denominators are unity, the squared distance between La Romana and San Pedro de Macoris and the squared distance between La Romana and Guaymate.

Population estimates for each of the cities were developed based on the latest Dominican Republic census data as reported by the Population Reference Bureau (1992). All population estimates were augmented to reflect anticipated intercensual increases in the population sizes of each city between January 1990 and May 1992, when the study began (Shryock, Siegel & Associates, 1976). Distances between the cities were measured using average travel time by public transport between the central plazas of each town.

Programme effect

A series of Knowledge, Attitudes and Practices (KAP) surveys were conducted among three distinct cross-sectional samples of women in identified commercial sex

establishments in La Romana, San Pedro de Macoris and Guaymate at three points in time: baseline (T_1), 4 months later (T_2) and after 8 months of the intervention (T_3).

Convenience samples of women were selected in each city at each point in time. Women located in places recognized as CSEs in the cities in question, and who agreed to be interviewed, were included in the samples. Women associated with these establishments are recognized within the general typology of commercial sex workers worldwide, as well as in the Dominican Republic (Symanski, 1981; De Moya, 1988; Pareja & Rosario, 1992).

Sample size

In order to detect a 20% increase in reported condom use, and assuming that at least 30% of CSWs were already using condoms at T_1, a significance level of 0·05 (alpha value), and a power (1-beta) of 0·80, the size of the sample was set at 71 pre-intervention and 71 at each of the follow-up points for each of the cities included in the study (Fleiss, 1981).

The sample size calculation was based on the scale of the city-to-city analysis. The city-to-city analysis compared the KAP results between La Romana and San Pedro de Macoris, and La Romana and Guaymate. The sample sizes for the cities of La Romana and San Pedro de Macoris were large enough to make the desired interurban comparisons. However, the smaller population base in Guaymate led to an inability to interview the desired numbers of women, creating some difficulties in interurban comparisons involving Guaymate, as well as all analyses stratified below the level of the city.

The main outcome variable was reported condom use. It was measured in three ways: condom use at the last act of intercourse (dichotomized as yes or no), condom use during the last five acts of intercourse (dichotomized as more regular, 4 or 5/5; or less regular, <4/5) and current condom use with the respondent's steady partner (dichotomized as yes or no). For the purpose of this paper, only positive responses were reported for all condom use variables.

Age and education were the two demographic variables in the analysis. Ages were grouped into three categories: <20, 20–29 and 30 or more years of age. Education was dichotomized into <6, or 6 or more years of schooling completed, which represents the completion of a primary school education in the Dominican Republic. Due to the small sample sizes, the results of these analyses are not reported in this paper.

Data analysis

Data were entered and preliminary analyses were conducted using the Epi Info, version 5·01 (Dean *et al.*, 1990). Overall percentage increases in condom use measures were compared at T_1, T_2 and T_3 by city. A two-tailed Fisher's exact test was used to examine differences at each time point within each city (Blalock, 1979). Ninety-five per cent confidence intervals (CI) were used to test statistical significance. Vector

Table 1. Urban characteristics, population estimates and measures of interconnectivity

	La Romana	San Pedro de Macoris	Guaymate
1992 population	94,917	84,917	14,343
Travel time from La Romana	NA	45	35
Population interaction potential	83·4	67·9	1·9

maps were constructed using the GIS to assess peer educator activity areas linking the three communities.

Results

Evolution of the intervention

Between June 1st 1992 and January 31st 1993, 32 CSWs were recruited and trained to become peer educators by the project. The peak number of active peer educators was reached in November. Only twenty peer educators were reporting in January, reflecting a 37% drop from the observed peak during the month of November (data not shown).

Figure 1, a vector map, illustrates the relative intensity of peer educator movement at the interurban scale. Lines represent the individual peer educator mobility within the study area by T_3. Peer educator movement is shown that linked the targeted city of La Romana with the proximate cities of San Pedro de Macoris and Guaymate. Nearly one-half (21/45) of the CSEs in La Romana were being visited by peer educators by T_3, suggesting that an important proportion of high-risk venues in the targeted city were being served by the project. Some peer educator activity was also reported in the proximate cities during the same time period. In San Pedro de Macoris, peer educator activity was directly reported from 6% (2/32) of the identified CSEs by T_3. During the same time interval, 22% (2/9) of the CSEs in Guaymate had been visited by a project-affiliated peer educator.

This interurban linkage between peer educator and CSEs in the three cities is consistent with the high degree of interconnectivity between the cities of La Romana, San Pedro de Macoris and Guaymate. Table 1 summarizes three diffusion-related characteristics of the urban places examined during this study: population size, travel time between the target and proximate cities and the output from the gravity model. The cities might be described as an urban hierarchy in which La Romana enjoys the dominant position given its relatively large population base, as compared with the other two cities (Beavon, 1977; Hagget, 1983).

The population of La Romana is about 12% greater than the population of San Pedro de Macoris and about 6·5 times larger than the population of Guaymate. On average, the distance between La Romana and San Pedro de Macoris can be travelled by bus in 45 min. The travel time between La Romana and Guaymate averaged 35 min, and that between San Pedro de Macoris and Guaymate is 80 min by bus. The results from the application of the gravity equation indicate that La Romana has a

Table 2. La Romana: percentage yes response on condom use variables by time

	T_1	T_2	T_3
Last coitus	73·1 (n=78)	86·1 (n=79)*	96·2 (n=79)*
Last 4 or 5 coital acts	52·0 (n=75)	76·3 (n=80)*	89·9 (n=79)*
With regular partner	36·1 (n=72)	36·5 (n=74)	48·1 (n=54)

*Denotes statistical significance at p=0·05.

nearly 20% greater level of potential population interaction than San Pedro de Macoris, and nearly 80% larger than Guaymate.

Condom use outcomes as measured in KAP surveys

In general, the samples drawn in each of the three locations were comparable across the three time periods, within and between cities. The majority of the women interviewed at each time period, in each city, were between 20 and 29 years old. The majority of the women interviewed in each city reported fewer than 6 years of formal education (data not shown).

Baseline condom use by city

Baseline levels of condom use among the CSWs interviewed are reported in Tables 2, 3 and 4. In general, reported condom use at last act of intercourse was higher at baseline than was expected. Women in Guaymate at baseline reported the lowest levels of condom use at last intercourse (53·5%). In contrast about three-quarters of the women in San Pedro de Macoris (74·7%) and in La Romana (73·1%) reported using a condom at the last act of intercourse at baseline.

No significant differences were noted between the cities on reported condom use during the last five acts of intercourse at T_1. The CSWs interviewed in all cities reported relatively high levels of condom use during the last five acts of intercourse, with roughly one-half of the respondents in each city reporting using condoms at least 80% of the time.

Condom use was less common with a person considered a steady partner or boyfriend. Seven out of ten (70·7%) women interviewed in Guaymate at baseline indicated that they did not use condoms with their regular partner. At the same time period, roughly six out of ten of the women in La Romana (63·9%) and San Pedro de Macoris (57·1%) reported not using condoms with regular partners or boyfriends.

Reported changes in sexual practices by city

The targeted city of La Romana. Table 2 presents the data on condom use at T_1, T_2 and T_3 among women interviewed in La Romana. A steady increase in the reported use of condoms at the last act of intercourse was noted. These reported changes were statistically significant at both T_2 and T_3 (p=<0·05). It is noteworthy

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Table 3. San Pedro de Macoris: percentage yes response on condom use variables by time

	T_1	T_2	T_3
Last coitus	74·7 (n=75)	75·6 (n=78)	92·5 (n=80)*
Last 4 or 5 coital acts	57·5 (n=73)	66·2 (n=77)	86·1 (n=79)*
With regular partner	42·9 (n=70)	45·6 (n=68)	40·6 (n=64)

*Denotes statistical significance at p=0·05.

that this trend was established by T_2 in the targeted city of La Romana after only 4 months of exposure to the intervention.

A similar positive trend is reported for condom use during the last five acts of intercourse. A steady increase in regular use of condoms is reported across the three time points, from a baseline of 52%, to 76·3% at T_2, and finally to 89·9% at T_3. This reflects an 82% increase in the regular use of condoms among CSWs in the target community of La Romana.

In contrast to these positive trends, only a slight change was reported at the three time periods regarding the use of condoms with steady partners or boyfriends among the CSWs in La Romana. As presented in Table 2, 36·1% of the women at baseline, 36·5% at T_2 and 48·1% at T_3 reported using condoms with their regular partner or boyfriend.

The proximate city of San Pedro de Macoris. As reflected in Table 3, between baseline and T_3 in San Pedro de Macoris there is a statistically significant increase in the percentage of women reporting condom use at the last act of intercourse ($p \leq 0{\cdot}05$). Seventy-four per cent of the women at T_1, a similar percentage at T_2 (75·6%), and over 90% (92·5%) at T_3 reported using a condom during their last coitus.

A similar trend is observed among the women interviewed in San Pedro de Macoris regarding condom use during the last five acts of intercourse. Reported condom use in at least four out of five of the last five acts of intercourse increased from 57·5% at T_1 to 86·1% at T_3 among CSWs in San Pedro de Macoris. This reported increase in the regular use of condoms is statistically significant ($p \leq 0{\cdot}05$), and represents a 61% increase over 8 months in a city proximate to the one targeted with the intervention.

As in the case of La Romana, however, the data on the reported use of condoms with regular partners were less encouraging.

The proximate city of Guaymate. As presented in Table 4, the intervention in La Romana is coincident with reported increases in the frequency of reported condom use among women engaged in the commercial sex industry in Guaymate. At baseline, over one-half (53·5%) of the women interviewed in Guaymate reported using a condom at the last act of intercourse. After 4 months, approximately two-thirds (67·4%) of the women interviewed in Guaymate report using a condom at last

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Table 4. Guaymate: percentage yes response on condom use variables by time

	T_1	T_2	T_3
Last coitus	53·5 (n=43)	67·4 (n=43)	75·6 (n=41)*
Last 4 or 5 coital acts	46·5 (n=43)	50·0 (n=42)	61·0 (n=41)
With regular partner	29·3 (n=41)	15·5 (n=38)	32·5 (n=40)

*Denotes statistical significance at p=0·05.

intercourse. At T_3, the percentage reporting condom use at last coitus increased to three-quarters (75·6%), representing a 50% increase over the 8-month study period. The reported change between T_1 and T_3 was statistically significant ($p \leq 0{\cdot}05$).

A similar pattern is observed regarding condom use during the last five acts of intercourse. Among women interviewed in Guaymate at T_1, less than one-half of the individuals interviewed reported using a condom during at least four of the last five acts of sexual intercourse. By T_2 this percentage had increased to 50%, while at T_3 the percentage of women reporting regular condom use increased to over 60% (61·0%), reflecting a 25% increase that was not statistically significant.

As was observed in La Romana and San Pedro de Macoris, little change was reported in Guaymate regarding the reported use of condoms with steady partners or boyfriends from T_1 to T_3.

Discussion

These data suggest that a targeted HIV/AIDS intervention that employed peer educators in the city of La Romana was temporally coincident and programmatically linked to the observed changes in reported condom use in that city. Moreover, the intervention in La Romana may be associated with the reported condom use outcomes in the proximate cities of San Pedro de Macoris and Guaymate.

The general levels of interurban attraction reported in this paper suggest diffusion pathways that link the three cities examined. Data on the mobility patterns of the peer educators involved in this project suggest that a targeted intervention in one community can affect neighbouring communities as well. Peer educators recruited in La Romana reported project-related education activities in the two proximate cities during the time frame considered in this study.

Rogers suggests that a threshold level exists (15%) before a diffusion impact can be noted (Rogers, 1971). An examination of the reports collected from the peer educators recruited in this project by T_2 indicates that this threshold was crossed in the case of La Romana where nearly 50% (21/45) of the CSEs were being visited by a project-affiliated peer educator. This suggested threshold was not met in San Pedro de Macoris, although a peer educator had visited an appreciable proportion of CSEs (2/32) in this city by T_2. This threshold was met in the case of the smaller proximate city of Guaymate, where slightly over 15% (2/9) of the peer educators reported activities by T_2. It seems that peer educator activity in CSEs in San Pedro de Macoris

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and Guaymate could have seeded a diffusion-assisted trend towards greater levels of safer sex practices reported in these two proximate cities.

These indications of diffusion potential provide an interesting backdrop against which the reported changes in condom use can be evaluated. The data from the KAP survey suggest that the intervention is associated with the significant changes in reported condom use at last act of intercourse and reported condom use during the last five coital acts among female CSWs in La Romana. This finding is consistent with the literature on HIV/AIDS behaviour change interventions (Moses *et al.*, 1991; Ngugi *et al.*, 1988; Potts *et al.*, 1991; Wilson *et al.*, 1990; Suarez *et al.*, 1990; Asamoah *et al.*, 1994; Ngugi *et al.*, 1996) and suggests that targeted prevention messages delivered by a trained cadre of peer educators can have a positive effect on a community of commercial sex workers.

It is important to note that these findings suggest that the intervention itself appeared to be well implemented. The project's service statistics system indicates a growth trend in terms of effective peer educators throughout November 1992. It should be noted that the steep drop-off in the intervention observed in December 1992 and January 1993 occurred just prior to the collection of the final follow-up data in the study. It is plausible, therefore, that the behaviour changes observed at T_3 could be a minimum estimate of the true effect of the intervention at the level of the targeted city, as well as the level of the proximate cities.

The reported changes in condom use in San Pedro de Macoris and Guaymate provide intriguing evidence that a targeted intervention with peer education in one city can influence behaviours in a proximate city. This observation is consistent with diffusion theory and provides important programmatic insights for the development of larger, more epidemiologically relevant HIV/AIDS prevention programmes that employ peer education outreach strategies. At the same time, these findings raise a note of caution for researchers using experimental designs to evaluate community interventions. They suggest that control sites could be influenced by an intervention in a geographically proximate community, potentially contaminating the results of expensive but much needed controlled trials of HIV/AIDS interventions.

The results of this study suggest that it might be possible to harness the phenomenon of diffusion if one considers naturally occurring urban hierarchies, such as the one examined in this case. The mobility of commercial sex workers confirmed in this study, and presumably that of their clients, and the population potential of urban places underscore the possibility of utilizing diffusion to expand the range of effectiveness of a peer education programme.

The degree of interconnectivity between La Romana and San Pedro de Macoris, revealed in these analyses, is a function of the relatively large population bases and physical proximity of these two cities. Such factors enhance the potential for diffusion pathways that link these cities. With approximately one-seventh of the population base of La Romana, and one-fifth of the population base of San Pedro de Macoris, the expected interaction between Guaymate and its neighbouring city of La Romana is clearly less intense than the expected interaction between La Romana and San Pedro de Macoris. Nevertheless, the dominant position of La Romana in the region and its relative proximity to Guaymate creates opportunities for diffusion pathways to exist for the dissemination of the safer sex messages generated from this project.

The limits of this process of geographical diffusion remain undefined, since this study operated in a context created for the purposes of testing the question posed in this study. Nevertheless, it is intriguing to consider the limits in terms of time and distance.

Although secular trends in overall condom use and HIV/AIDS awareness might account for the changes observed in the proximate cities of La Romana and Guaymate, the evidence presented here is consistent with a diffusion effect. The data suggest that the intervention in La Romana had an influence in San Pedro de Macoris, and to a lesser degree, in the smaller city of Guaymate. The distance separating La Romana from San Pedro de Macoris and Guaymate did not overwhelm the peer educator-carried message among these cities.

These findings have important implications for organizations seeking to address the HIV/AIDS prevention needs of targeted communities around the world. Countries that enjoy similar levels of development as those observed in the Dominican Republic with good communication and transportation systems, seem ideal for harnessing diffusion as a means of extending the reach of targeted interventions. Programmes should examine the natural occurring diffusion pathways, such as the one observed in this study, as they develop strategies to meet the challenge of escalating HIV/AIDS rates in many parts of the developing world.

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