HHS Public Access

Author manuscript

Int J Disaster Risk Reduct. Author manuscript; available in PMC 2016 September 01.

Published in final edited form as:

Int J Disaster Risk Reduct. 2016 September ; 18: 162–160. doi:10.1016/j.ijdrr.2016.04.016.

Handheld solar light use, durability, and retention among women and girls in internally displaced persons camps in Haiti — 2013–2014

Michelle Dynes[a,*], **Mariana Rosenthal**[b,c], **Erin Hulland**[d], **Colleen Hardy**[d], **Lisandro Torre**[d], and **Barbara Tomczyk**[c]

[a]Epidemic Intelligence Service, Center for Global Health, Centers for Disease Control and Prevention, 1600 Clifton Road, Atlanta, GA 30329, USA

[b]Epidemic Intelligence Service, Centers for Disease Control and Prevention, 1600 Clifton Road, Atlanta, GA 30329, USA

[c]Idaho Department of Health and Welfare, 3402 Franklin Rd, Caldwell, ID83605, USA

[d]Center for Global Health, Centers for Disease Control and Prevention, 1600 Clifton Road, Atlanta, GA 30329 USA

Abstract

During conflict and disasters, women and girls are at increased risk of gender based violence. International humanitarian guidelines call for the distribution of individual lighting to meet women and girls' basic needs and to reduce risk of violence; however, little evidence exists to support these guidelines. This paper presents an evaluation of handheld solar light use, retention, and durability among women and girls living in two internally displaced persons camps in Port-au-Prince, Haiti. Data was gathered prospectively via five household surveys from August 2013 to April 2014; a total of 754 females participated in the study. Women reported going outside at night more frequently at the end of the study than at the beginning. The handheld solar lights were the most common source of lighting at endline, whereas candle and gas lamp use declined significantly over time. Results from a Life-Table survival analysis estimated that households had an 83% probability of still owning a functioning light after seven months. Given the frequent use, acceptable durability, and retention of the lights, donors and humanitarian organizations should consider supporting light distribution to women and girls in internally displaced persons camps to help meet their basic needs.

Keywords

Disasters; Haiti; Solar lights; Gender based violence

[*]Corresponding author. Present address: 4770 Buford Hwy NE, Atlanta GA 30341, USA. mdynes@cdc.gov (M. Dynes).

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention (CDC) or the International Rescue Committee (IRC).

1. Introduction

Key actions are needed to integrate the protection principles of safety and dignity and avoidance of harm in the delivery of humanitarian assistance to conflict and disaster affected populations. The Sphere Project Humanitarian Charter and Minimum Standards in Humanitarian Response first addressed artificial lighting specifically for protection in 2004, with refinement of the guidelines in 2011 [1,2]. Both the Sphere and Inter-Agency Standing Committee Guidelines for Gender Based Violence suggest key strategies to minimize night-time risks including installing overhead lights, distributing personal handheld flashlights, incorporating a buddy system, and advocating for regular monitoring by community watch and security personnel [1–3]. While the recommended types of lighting have transitioned from candle and lantern use to the inclusion of light emitting devices (LED), the underlying reason for providing them has not – for personal safety in the house and when visiting the latrine and engaging in other night-time activities [1,2].

1.1. Gender based violence risk for women and girls

During conflict and disasters, women and girls are at increased risk of gender based violence due to the exacerbation of gender inequities and the destabilization or destruction of systems that usually protect them [3,4]. Specifically, women and girls may experience sex trafficking, forced labor, sexual coercion, and may be approached for sexual acts in exchange for assistance and protection. When displaced, women and children may be subjected to gender based violence by persons in authority or approached for sexual acts in exchange for protection and assistance. They are vulnerable when using communal water and sanitation facilities, during food distributions, and fuel collection, particularly at night or in dark places [5]. Some of the contributing factors for gender based violence during displacement include loss of security, lack of economic livelihoods, alcohol, drug use, psychological trauma, disrupted roles within the family and community, and lack of knowledge about one's individual rights [6].

1.2. Gaps in the research evidence

Little research has been conducted, however, on the effectiveness of interventions on risk reduction to violence [7–11], and information on how to implement and measure the impact of interventions in local contexts is limited [12]. Recently, governments and United Nations agencies have taken important steps towards decreasing risks due to gender based violence among women and girls affected by conflict and disasters. For example, the United States National Action Plan on Women, Peace and Security released in November 2011 attempts to empower and protect women through designing and implementing relief to recovery assistance activities in ways that reduce the risks and consequences of gender based violence [13]. Evidence has shown that when more emphasis is placed on promotion and inclusion of women in humanitarian assistance, gender based violence programs have a greater chance of success [14].

Due to the potential heightened vulnerability of women and children at night and in dark areas, it has been suggested that distribution of solar lights to displaced people may improve sense of safety and risk from physical and sexual violence [15–22]. Other suggested benefits

of solar lights include one's ability to see animals or insects [23,24], homework study conditions for children [15–17,23–27], access to economic opportunities [17,19,22,25,26], and reduce health hazards from fire and environmental pollutants [16,17,19,27]. While these and other unpublished reports describe the benefits of solar lights among displaced populations, there are no published research studies in peer reviewed literature that have attempted to describe and quantify how the lights are used in day to day life, how durable the lights are, and their impact on use of other sources of lighting and women and girls' sense of safety. Moreover, most evaluations have used focus group discussions or cross-sectional surveys to assess the impact of lighting which are limited in various respects. For example, focus group discussion participants are not selected at random and may provide answers they think the interviewer or other group members want to hear or will give them favorable treatment [28,29]. Cross-sectional surveys are done at only one point in time and do not allow for comparison of results longitudinally [30]. An additional constraint of current evaluations is that they have had short follow-up periods between distribution of lights and evaluation which limits information about the durability and retention of the lights over time [18,19].

Since 2010, the United States Agency for International Development Office of Foreign Disaster Assistance has received several requests to fund handheld solar lights as a means of preventing gender based violence in displacement settings. Limited evidence is available, however, on the outcomes of using solar lights in these settings. For example, will women and children find the lights acceptable to use? How often and for what purpose will the lights be used by women and children? Will the lights be durable enough over time to recommend their continued funding in post-humanitarian crisis environments? Solar lights cannot offer protection from gender based violence or improve sense of safety if women and children choose not to use them. Before the humanitarian community can justify continued funding of solar lights as a protection intervention, robust evidence is needed that demonstrates acceptability and use of the lights by women and children, and the durability of the lights over time.

1.3. Post-earthquake Haiti

The 2010 earthquake that struck Port-au-Prince, Haiti, resulting in the deaths of over 230,000 people [31]. The International Rescue Committee's gender based violence assessments in post-earthquake Haiti in 2012 identified increased risks to women and girls living in internally displaced persons camps in Port-au-Prince, Haiti. Key findings showed poor lighting, congested sleeping spaces, and a lack of appropriate bathing facilities, hygiene materials, and shelter [21,32].

1.4. Evaluation study of handheld solar lights

In an effort to help fill the research gaps, an evaluation was carried out with the goal of documenting the use and benefits of handheld solar lights and to explore the sense of safety among females aged 14 years and older living in two camps in Port-au-Prince, Haiti. These two internally displaced persons camps were constructed in the aftermath of the 2010 earthquake. The purpose of the current paper is to use survey data to describe the use,

durability, and retention of handheld solar lights in order to build the research evidence to ensure that the humanitarian community has the most effective tools and guidelines in place.

2. Methods

2.1. Study design and site selection

A mixed methods study design guided by The Centers for Disease Control and Prevention's Framework for Program Evaluation in Public Health was employed to gather qualitative and quantitative data prospectively over a 9-month period (August 2013–April 2014) [33]. We conducted one household survey at baseline, three household monitoring surveys and one endline survey. We also conducted eight focus group discussions at baseline and eight at endline with a total of 80 and 82 participants, respectively. While both qualitative and quantitative data were collected during the course of the study, this paper focuses on the quantitative findings. The protocol was approved by the Haitian Ministry of Public Health and Population.

The evaluation was carried out in Camp Toto and Camp Sinai because they had (i) an existing IRC program, (ii) an existing formal camp management system, and (iii) camp stability, defined as the camp was scheduled to remain open for the duration of the evaluation. The two camps had a combined population of 5783 (Toto 4297; Sinai 1486), with an estimated 2057 females aged 14 and older in July 2013. Camp Toto had large solar panels for street lighting and Camp Sinai lacked street lighting. Eligible participants in the evaluation were (i) females aged 14 and older, (ii) living in households in the two camps, and (iii) who spoke Haitian Creole.

The International Rescue Committee distributed the d.light S300 Solar Lantern per household in September 2013 after the baseline survey [34]. This model of light was selected due to preference among women in Port-au-Prince during a rapid trial period and the availability of the lights locally [35].

2.2. Sampling frame and sample size calculations

The sampling frame and sample size calculations for the evaluation were based on the March 2013 International Organization for Migration Camp Registration Database. The sample size was calculated separately for the two main evaluation indicators (i) light use and (ii) light retention. We also took the sense of safety indicator into consideration when calculating sample sizes; however, it is not the focus of this paper.

A Kaplan-Meier survival function approach was used to estimate the change over time in light use and light retention indicators using no adjustment for an infinite population. Simulations estimated the change of each indicator and the precision of survival probabilities over time for different sample sizes. Using a fixed sample size of 300 females for Camp Sinai due to a limited camp population, a precision of ≤ 5.6% was estimated for the survival probabilities. For Camp Toto, where the sample size was not fixed, the precision target was ≤ 5%, which yielded a sample size of 400 households. We assumed that the use and failure of the solar light would increase over time. Using a fixed total sample size of 700 estimated from the Kaplan-Meier simulations and a precision of ≤ 5.6% and an alpha of

0.05, power calculations were run for three different sense of safety indicator scenarios including a 5% absolute change from baseline to endline, a 10% camp difference, and a 10% age difference; all calculations yielded power estimates greater than 80%. The sample size of 700 women was increased to 875 women to account for an assumed non-response rate of 20%. All sample size and power calculations were run in SAS version 9.3 [36].

2.3. Selection of participants

A stratified two-stage cluster sampling was employed based on the different sample sizes of each camp. A household was defined as a group of individuals who stayed in the household and ate from the same pot during the two weeks prior to the survey date. We developed this household definition through discussions with interviewers on how a household would be described in Haiti and in consideration of previously established standards [37].

Camp Sinai was sampled exhaustively due to the similarity between the small population size and the targeted sample size. Camp Sinai and Camp Toto were divided into four and six approximately equal segments, respectively, using satellite images from Google Maps and a camp image from the Displacement Tracking Matrix site [38]. In Camp Toto, five of six segments were randomly selected, and one out of every two households within a segment was systematically selected with a random start.

For the second stage, all eligible females within the selected household were listed. If only one female was eligible in a household, she was selected. In households where there was more than one eligible female, the Kish Method was used to randomly select one of the females for participation [39]. The female randomly selected at baseline was followed over time whenever possible. In cases where the selected female was not available at a monitoring visit, another household member knowledgeable about light use among household members was interviewed. During the baseline, the original females selected who could not be traced after a minimum of three separate day return visits were recorded as absent. During the endline, in cases where the baseline-selected female was not available after three attempts, another eligible female was randomly selected using the Kish Method. Refusals and absentees were recorded and not replaced. Any person who did not have the capacity to respond to the questions due to mental or physical disabilities was excluded from the evaluation.

2.4. Data collection

The questionnaires were developed based on agreed upon indicators developed by the International Rescue Committee Women's Empowerment and Protection Team in New York and Haiti and Research, Evaluation, Learning Unit, in consultation with the Centers for Disease Control and Prevention and the United States Agency for International Development Office of Foreign Disaster Assistance. Focus group discussion data were used to improve overall understanding of concepts and in the development of survey questions. The draft set of questions were then tested with the survey team to ensure that questions were asked in accordance with the culture and language. Questionnaires were translated and back-translated into Haitian Creole. Household surveys were conducted in Haitian Creole at baseline (month 0), on a bi-monthly basis after distribution (months 1, 3 and 5), and at

endline (months 6–7). The questionnaire went through several revisions before being piloted among the population prior to the survey onset. Household surveys assessed the following:

- Baseline: night-time activities, sources of lighting
- Monitoring Visits: use, durability, and retention of lights
- Endline: night-time activities, sources of lighting, perception and use of lights, and durability and retention of lights

Following light distribution, an initial visit was conducted at week one to pilot the survey tools and replace any non-functioning handheld solar lights.

Twenty-two enumerators were trained for seven days in interview and consent techniques for the baseline and endline surveys. Four enumerators collected survey data at monitoring visits, with one day of initial training and a half day of refresher training with each subsequent monitoring visit. Informed verbal consent was obtained from all participants prior to data collection. If the selected female was aged < 18 years, assent was obtained by the interviewer only after a parent or guardian provided consent. Six data entry clerks received one day of training using Epi-Info. All enumerators and data entry clerks were trained on procedures to ensure privacy and confidentiality of participants.

2.5. Data analysis

Household survey data were double-entered and reconciled prior to analyses. Sampling weighting was not applied for the combined camp analyses. Descriptive analyses were conducted to assess the distribution of indicators. Chi-square and independent sample *t*-tests were used to compare categorical and continuous variables, respectively, by camp. In cases where cell sizes were small, Fisher's Exact Test was used in place of Chi-square analysis.

A Life-Table survival analysis was performed to estimate handheld solar light retention over time. Survival at each time point was calculated using the number of people who still had their lights, those who had lost their lights (e.g., theft), and those who were lost to follow-up. Loss to follow-up was defined as an individual who was not available for an interview at any subsequent visit.

Only households where the same female was interviewed at both baseline and endline were included in the analysis of lighting sources. The percentage of those who responded ‘yes’ to each outcome at baseline and endline, odds ratios, 95% confidence intervals and corresponding p-values were reported. In consideration of correlated outcomes due to repeated measures in the same subject, a generalized estimating equation model with a first-order autoregressive correlation structure was used with subject as the cluster [40]. All analyses were done using SAS Version 9.3 and figures were created using Microsoft PowerPoint and the survival package of R 3.1.0 [36,41–43].

3. Results

The final number and percentage of participants who completed the household surveys at each time point are as follows:

- Baseline N = 754 (84% of 895 attempted);
- Monitoring Visit 1 N = 650 (81% of 801 attempted);
- Monitoring Visit 2 N = 579 (77% of 754 attempted);
- Monitoring Visit 3 N = 572 (79% of 721 attempted); and
- Endline N = 634 (66% of 720 attempted).

Eighty-seven percent of the endline household survey participants were the same female from the same household as the baseline survey (n = 553; Camp Sinai n = 237, Camp Toto n = 316). There was a 29% loss to follow-up with the same female from baseline to endline survey; sixteen percent of attrition resulted from families having moved.

3.1. Participant characteristics

The average age of participants was 31 years (Table 1). More than half of participants reported some high school education (56.2%), while nearly one in 10 reported never attending school (9.3%). Nearly half of the households had four to five household members (43.5%). On average, participants reported living in the camps for 3.6 years. Differences were noted between the two camps. For example, 62.5% and 47.6% of participants from Camps Toto and Sinai, respectively, reported having attained some high school education ($p < 0.001$). More than 1 in 10 participants from Camp Sinai (12.9%) reported attaining no education, while only 6.6% of participants in Camp Toto reported attaining no education ($p < 0.001$).

3.2. Night-time activities

“Personal reasons” such as using the latrine was the most commonly reported night-time activity among participants in both camps at baseline and endline (Sinai 66.7% and 90.4%; Toto 68.2% and 77.4%) (Table 2). The odds of reporting going outside at night to buy water/food/gas/other were significantly increased at endline compared to baseline (Sinai OR = 5.33 and Toto OR = 5.52, $p < 0.001$). In Camp Sinai, the odds of reporting going outside at night for personal reasons were also significantly increased at endline compared to baseline (OR = 4.54, p-value < 0.001).

3.3. Perceptions and use of handheld solar lights

Nearly all endline participants (96.5%) reported they would recommend the handheld solar light to friends and family, and 92.3% of participants reported they felt the handheld solar light was better in comparison to other lighting sources such as gas lanterns and candles. Most endline participants (95.5%) reported using the handheld solar light at least once a day. Among those who reported going outside the home at night, 67.9% reported using the light in the last week. Six percent of endline survey participants reported not using the light when they went outside the home at night because the light was unavailable to them at the time they wanted to go out.

3.4. Sources of lighting

At endline, the handheld solar light was the most common lighting source reported for use both inside (Sinai: 81.9%; Toto: 87.1%) and outside (Sinai: 70.8%; Toto: 70.0%) the home among all lighting sources including telephone flash (Inside: Sinai 60.4% and Toto 63.6%; Outside: Sinai 52.8% and Toto 54.0%), public electricity (Inside: Sinai 61.2% and Toto 38.0%; Outside: Sinai 24.4% and Toto 10.5%), candles (Inside: Sinai 32.6% and Toto 21.5%; Outside: Sinai 12.9 and Toto 9.4%), traditional gas lamps (Inside: Sinai 7.4% and Toto 25.1%; Outside: Sinai 4.4% and Toto 7.7%), and flashlight (Inside: Sinai 9.6% and Toto 14.6%; Outside: Sinai 9.2% and Toto 12.4%). Eighty-seven percent and 83% of Camp Sinai and Toto households, respectively, reported not having a working flashlight excluding the handheld solar light.

Changes in use of light sources inside the home were noted from baseline to endline (Table 3). In Camp Sinai, the odds of reporting candle use and gas lamp use inside the house were significantly decreased at endline compared to baseline (OR = 0.06, OR = 0.38, respectively, both p-values < 0.001). Similarly, in Camp Toto, the odds of reporting candle use, gas lamp use, phone light use and flashlight use inside the house at endline were all significantly decreased compared to baseline.

Changes from baseline to endline were also noted in the use of light sources outside the house at night (Table 3). In Camp Sinai and Camp Toto, the odds of reporting candle use outside were significantly decreased at endline compared to baseline (OR = 0.50, p-value 0.005 and OR = 0.37, p-value < 0.001, respectively). In Camp Sinai, the odds of reporting phone use as a source of lighting were increased at endline compared to baseline (OR = 1.48, p-value 0.030). In Camp Toto, the odds of reporting flashlight use were decreased at endline compared to baseline (OR = 0.59, p-value 0.004).

3.5. Durability and retention of the handheld solar lights

Participants reported an average of 5.3 h to charge the light. Three-quarters of participants reporting nothing had broken on the light (76.2%) at endline. Among participants who reported breakage, one-third (32.6%) reported the light still works. Among the 18 participants who reported having their light fixed, 72.2% said they did not have to pay to have it fixed. (Table 4).

Among participating households, 84.2% still owned the handheld solar light seven months following initial light distribution (Fig. 1). Eighty-six percent of these households, at endline, presented the light and solar panel upon request, with 93.7% of these lights being fully charged or on the charger. Among those who did not present their light, but reported still owning it, 47.2% reported it was being charged away from the house, 16.7% let someone borrow it, and 12.5% reported it was being used by a family member away from the house.

Among participants who no longer owned the light at endline, 69.6% reported theft, 12.0% reported breakage, and 9.8% reported gifting the light and/or panel. Participants reported having the light for an average of 1.6 months before loss. Participants in Camp Sinai were

significantly more likely to report the light and/or panel was stolen compared to those in Camp Toto, respectively (80.0% and 57.1%; p = 0.010).

The probability of having the light at monitoring visit 1 via survival analysis was 96.1%; 29 participants had lost their light (e.g., stolen) and another 28 were lost to follow-up (labeled as censored) between baseline and monitoring visit 1 (Fig. 2). The probability of having the light at monitoring visit 2 was 92%; 30 participants lost their light and 12 participants were lost to follow-up between monitoring visits 1 and 2. The probability of having the light at monitoring visit 3 was 88.3%; 26 participants lost their light and 12 participants were lost to follow-up between monitoring visits 2 and 3. Finally, the probability of having the light at endline was 83.0%; 36 participants lost their light and 52 participants were lost to follow-up between monitoring visit 3 and endline. At endline, 533 of the original 758 participants still had their light; 121 participants had lost their light during the course of the evaluation.

4. Discussion

The handheld solar lights were the most common source of indoor and outdoor lighting in both camps; a high proportion of participants reported daily use and would recommend it to friends and family. These results are consistent with other evaluations where solar lights have been found to have high acceptability and use among displaced populations [18,23,24]. We also found that similar use of the handheld solar lights was reported despite differences in the presence of large outdoor solar panels between camps. Moreover, indoor and outdoor use of candles and gas lamps decreased from baseline to endline in both camps. This finding is important because candles and kerosene use can result in fires and exposure to toxins, leading to major morbidity and mortality in developing countries [44]. While we cannot attribute the reduction in use of candles and gas lamps to the alternative use of solar lights (due to lack of a control group in the evaluation), the apparent trend would be interesting to explore with future research. We also found both anecdotally and from the survey that effort was taken by the participants to ensure their solar lights were not stolen (e.g., keeping the lights locked away, charging in another location) which supports the conclusion that the lights were a valued commodity.

We found that the lights were retained to a high degree and had acceptable durability given the conditions of the camps. Households had an 83% probability of still owning the light after 7 months, and more than three-quarters of participants reported no breakage after 7 months. These findings mirror results from other evaluations where most of the distributed handheld solar lights were retained and used; however, prior evaluations were limited by short periods between light distribution and evaluation (from only five days to three months) [18,19]. Our findings of high retention and satisfactory durability of the solar lights are important contributions to the current literature because they can help guide future allocation of limited resources in humanitarian settings; well-intentioned donations of equipment are often made without understanding of the appropriateness of the equipment in particular settings [45].

While it is important to reflect on the benefits of the handheld solar lights, it is equally important to consider the safety and security implications and potential unintended

consequences related to solar light distribution. We found that women and girls were more likely to report certain night-time activities outside the home at the end of the evaluation (when they had the lights) compared to the beginning (before light distribution). While we are unable to attribute this change directly to the presence of solar lights, it raises important questions including:

- How does access to handheld solar lights change women and girls' responsibilities and expectations due to being able to do more night-time activities?;
- Are women and girls at greater risk for gender based violence if solar lights lead to increased night-time activities outside the home?;
- What additional strategies are needed to ensure women and girls are safe when they leave their homes at night?; and
- Are there other potential unintended consequences of handheld solar light distribution?

Evaluations have reported that the presence of solar lights has resulted in women having reduced time for reading and socializing in the evenings due to deferring domestic work to the evening hours [25], and increased fear due to being a potential target of theft or revealing one's location [17]. Moreover, without external funding, solar lights are often unavailable or unaffordable to displaced communities [46]. Among the handheld solar light models pretested for this evaluation, we found a considerable range in prices from 10 to 50 United States dollars per unit [35]. Careful consideration needs to be given to the unit cost of handheld solar lights (50 United States dollars for this evaluation), potential benefits, and the expected length of life of the lights prior to future distributions.

To date, several campaigns and initiatives claim great benefits resulting from the distribution of solar light sources among displaced populations. However, this is the first scientific study, to our knowledge, that provides statistical evidence of the acceptable durability and retention of handheld solar lights and their daily use by women and girls in internally displaced persons camps. Strong elements of this study include:

- Its longitudinal study design, which allows the detection of trends over time;
- Repeat interviews with the same 553 women and girls at multiple monitoring visits for a period of 7 months, enhancing our ability to assess the use and durability of the lights among a large population and reduce nonsystematic variance;
- Data collection from two internally displaced persons camps, one with solar street lighting and one without, allowing us to compare the influence of having street lighting on the use and retention of the handheld solar lights; and,

- Documentation of the specific outcomes of the lights (Fig. 1), to inform humanitarian and funding agencies during strategic planning of future funding in similar settings.

The United States National Action Plan on Women, Peace, and Security was designed to give women and girls equal participation in preventing conflict and building peace in countries threatened and affected by war, violence, and insecurity. Achieving this goal is possible through the collaboration among civil society, and humanitarian and government agencies. However, it is important that agencies establish mechanisms to promote accountability and protection of women and girls in humanitarian settings based on best practices. A clear priority for the respect of the protection needs of women and girls can help to guide targeted efforts aimed at providing and improving health services and policies in humanitarian crises [14]. Findings from this handheld solar light evaluation confirm the need to study and disseminate findings on handheld solar light distribution particularly since previous evaluations are not well documented. This evaluation can inform funders and policy makers by improving the understanding of how handheld solar lights are implemented and whether they achieve expected outcomes such as acceptability and durability.

4.1. Study limitations

There were a number of limitations related to this evaluation, the first of which is that we are unable to draw causal conclusions about the impact of the lights due to lack of a control group; we had ethical concerns regarding the denial of lights to a control group. The changing environment of the camps also limits the generalizability of this study to other camps in Haiti and elsewhere. This evaluation only assessed one type of handheld solar light and results may vary depending on the model of solar light used. Furthermore, social desirability bias may have played a role in participant responses if participants thought that positive responses would increase the likelihood of additional distributions of lights. Our generalized estimating equation analysis only used the “matched” females to increase precision of measurements which reduced our sample size to 553, resulting in a decrease in statistical power. Finally, weighting was not used in the analysis of combined data from both camps due to the use of different sampling strategies in the camps.

4.2. Future research

Qualitative and anecdotal evidence has implied that the distribution and use of handheld solar lights in humanitarian settings has benefits for women and girls, which are reflected in international guidelines for distribution of individual lighting in humanitarian settings. This evaluation conducted in two camps in Haiti has shown significant personal benefits of handheld solar lights and raises new questions about potential linkages to safety and security issues that women and girls face in camp settings. Future impact evaluations which incorporate the use of comparison groups, where feasible, are warranted. In order to build on the findings of this research, additional studies may focus on the following:

- To determine the utility and durability of lights, including other types of solar and non-solar, non-battery powered lights, as well as general lighting

provided at the community level in other settings and across various phases of emergencies;

- To contribute to knowledge about women and girls' access to and control over non-food items (NFIs) in the household;
- To explore the implications of handheld solar lights on women and girls' responsibilities and expectations and susceptibility to gender based violence related to being able to do more nighttime activities;
- To explore strategies that can be combined with handheld solar lights to reduce any potential risks women and girls may face as their mobility at night is increased; and
- To explore and quantify the impact of handheld solar lights on quality of life (e.g., ability to do homework, socialize at night).

5. Conclusions

Women and girls from two internally displaced persons camps in Port-au-Prince, Haiti reported using the distributed handheld solar lights regularly. The solar lights seem to have addressed a gap for women and girls: access to a consistent portable lighting source. In the seven month span of the evaluation, and throughout both camps, the handheld solar lights were shown to be adequately durable and high retention rates were reported. Given the use, durability, and retention of the evaluated handheld solar lights, donors and humanitarian organizations should consider supporting their distribution to women and girls in camps.

Acknowledgments

This evaluation would not have been possible without the collaborative efforts of numerous individuals from the International Rescue Committee (IRC) Women's Protection and Empowerment Technical Team, CDC Atlanta, IRC and CDC country offices in Haiti, and the women and girls who participated in the interviews. Funding was provided by United States Agency for International Development Office of Foreign Disaster Assistance (OFDA) and CDC (3UE2EH000611-04S1). This research was also supported in part by an appointment to the Research Participation Program at the CDC administered by the Oak Ridge Institute for Science and Education through an interagency agreement between the US Department of Energy and the CDC. The authors also wish to thank Leora Ward and Kathryn Falb, IRC, for comments on the final paper.

References

1. 2004. , editor. 2014. Sphere Project, Sphere handbook: Humanitarian charter and mnminimum standards in disaster response. ⟨http://www.refworld.org/docid/3d64ad7b1.html⟩ [accessed 03.02.15]
2. 2011. , editor. 2011. Sphere Project, Sphere handbook: Humanitarian charter and minimum standards in humanitarian response. ⟨http://www.refworld.org/docid/4ed8ae592.html⟩ [accessed 03.02.15]
3. Inter-Agency Standing Committee. Geneva: Inter-Agency Standing Committee; 2005. Guidelines for Gender-based Violence Interventions in Humanitarian Settings: Focusing on Prevention of and Response to Sexual Violence in Emergencies (Field Test Version).
4. Krug EG, Mercy JA, Dahlberg LL, et al. The world report on violence and health. Lancet. 2002; 360(9339):1083–1088. [PubMed: 12384003]
5. Jeanne W. If not, ward now, when? Addressing gender-based violence in refugee, internally displaced, and post-conflict settings: a global overview. The reproductive health for refugees

consortium. 2002 [accessed 19.04.16] Available from: ⟨https://www.womensrefugeecommission.org/resources/239-refugee-protection/240-if-not-now-when-addressing-gender-based-violence-in-refugee-internallydisplaced-and-post⟩.

6. United Nations High Commission for Refugees, sexual and gender based violence against refugees, returnees, and internally displaced persons guidelines for prevention and response. 2003 [accessed 19.04.16] Available from: ⟨http://www.unicef.org/violencestudy/pdf/UNHCR%20-%20SGBV.pdf⟩ 0.2003.
7. Lyytinen E. Reseach Paper No. 172: Household energy in refugee and IDP camps: challenges and solutions for UNHCR. 2009 [accessed 23.07.14] ⟨http://www.unhcr.org/4a1d2f422.html⟩.
8. Republic of Haiti, Gender-based violence against haitian women & girls in internal displacement camps, 2011. Submission to the United Nations, Universal Periodic Review. [accessed 03.02.15] ⟨http://ijdh.org/wordpress/wp-content/uploads/2011/03/UPR-GBV-Final-4–4-2011.pdf⟩.
9. Spangaro, J.; Zwi, A.; Adogu, C., et al. EPPI-Centre, Social Science Research Unit. London: Institute Of Education, University Of London; 2013. What is the Evidence of the Impact of Sexual Violence in Conflict and Post-conflict Zones and Other Humanitarian Crises in Lower- and Middle-income Countries? A systematic review.
10. United Nations High Commissioner for Refugees (UNHCR). UNHCR handbook for the protection of women and girls. 2008 [accessed 03.08.12] ⟨http://www.unhcr.org/refworld/docid/47cfc2962.htmlhttp://www.unhcr.org/refworld/docid/47cfc2962.html⟩.
11. United Nations High Commissioner for Refugees (UNHCR). Protecting refugee women: promoting gender equality. 2011 [accessed 23.07.14] ⟨http://www.unhcr.org/4de4f71a9.html⟩.
12. Stark L, Ager A. A systematic review of prevalence studies of gender-based violence in complex emergencies. Trauma Violence Abus. 2011; 12(3):127–134.
13. The White House. Washington: 2011. United States national action plan on women, peace, and security. ⟨http://www.whitehouse.gov/sites/default/files/email-files/US_National_Action_Plan_on_Women_Peace_and_Security.pdf⟩ [accessed 28.07.14]
14. Holmes R, Bhuvanendra D. Preventing and responding to gender-based violence in humanitarian crises. Humanitarian Practise Network at Overseas Development Institute. 2014; 77 [accessed 28.01.15] ⟨http://www.odihpn.org/hpn-resources/network-papers/preventing-and-responding-to-gender-based-violence-in-humanitarian-crises⟩.
15. Benoit-Xavier F. Renewable energy in the camps of Tamil Nadu. Force Migr. Rev. 2011; 37:48–49. [accessed 04.02.15] ⟨http://www.fmreview.org/non-state/Benoit-Xavier.html⟩.
16. Farrell J. Promoting literacy and protection with solar lamps in Yemen. Stab.: Int. J. Secur. Dev. 2014; 3(1):15. http://dx.doi.org/10.5334/sta.dm.
17. Gunning R. The current state of sustainable energy provision for displaced populations: an analysis, Energy, Environment and Resources, The Chatham House. The Royal Institute of International Affairs. 2014 [accessed 04.02.15] ⟨http://www.chathamhouse.org/sites/files/chathamhouse/field/field_document/20141201EnergyDisplacedPopulationsGunning.pdf⟩.
18. International Rescue Committee (IRC). Emergency Response and Preparedness Unit (ERPU) Waka Waka solar light field test report: Syria – Humanitarian response project 2012–2013. 2013 (unpublished program report).
19. Jewell J. Ending isolation: solar solutions in Haiti. Humanitarian Exchange Magazine. 2011; 51 [accessed 4 February 2015] ⟨http://www.odihpn.org/humanitarian-exchange-magazine/issue-51⟩.
20. Natta PM. Anchoring return: the role of the solutions strategy. Forced Migr. Rev. 2014; 46:13–14. [accessed 4 February 2015] ⟨http://www.fmreview.org/afghanistan/natta⟩.
21. International Rescue Committee (IRC). Women's protection & empowerment rapid assessment: Tabarre and Croix de Bouquet municipalities. Port-au-Prince Haiti. 2012a Unpublished program report.
22. UNHCR Division of International Protection. Action against sexual and gender-based violence: An updated strategy. 2011 [accessed 04.02.15] ⟨http://www.unhcr.org/4e1d5aba9.pdf⟩.
23. Elephant Energy. Namibia flood-relief energization plan final report. 2011 [accessed 04.02.15] ⟨http://www.elephantenergy.org/images/documents/Final_Report_-_Namibia_Flood_Relief_Energization_Plan__2011_.pdf⟩.

24. FAFI Integrated Development Association (FaIDA) and United Nations High Commissioner for Refugees. Testing the acceptability and suitability of Waka Waka solar lamps. 2013 [accessed 04.02.15] ⟨http://us.waka-waka.com/media/wakawaka_unhcr_faida_(1).pdf⟩.
25. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). GmbH, Solar lamps field test Uganda: Final report, Kampala. 2011 [accessed 04.02.15] ⟨https://energypedia.info/images/7/72/GIZ_Solar_Lamps_field_Report_Uganda_Webversion.pdf⟩.
26. Furukawa C. Thesis: Do solar lamps help children study? Contrary evidence from a pilot study in Uganda (Draft January 2013). 2013 [accessed 04.02.15] ⟨http://www.brown.edu/Departments/Economics/2013-undergrad_theses/Furukawa%20thesis.pdf⟩.
27. United Nations High Commissioner for Refugees (UNHCR). Light years ahead: Innovative technology for better refugee protection. 2012 [accessed 04.02.15] ⟨http://www.unhcr.org/4c99fa9e6.pdf⟩.
28. Leung FH, Savithiri R. Spotlight on focus groups. Can. Fam. Physician. 2009; 55(2):218–219. [PubMed: 19221085]
29. Smithson J. Using and analysing focus groups: limitations and possibilities. Int. J. Social Res. Methodol. 2000; 3(2):103–119.
30. Levin KA. Study design III: cross-sectional studies. Evidence-Based Dent. 2006; 7:24–25.
31. US State Department. [accessed 12.02.15] Fast facts on the U.S. government's work in Haiti – January 2011. 2015. ⟨http://www.state.gov/documents/organization/154357.pdf⟩
32. International Rescue Committee. Situational analysis: addressing vulnerability of and violence against women & girls in Carrefour-Feuilles. Port-au-Prince Haiti. 2012b Unpublished program report.
33. Centers for Disease Control and Prevention (CDC). Framework for program evaluation in public health. Morbidity and Mortality Weekly Report. 1999; 48(RR-11)
34. d.light S300: Mobile chargingɒlight. [accessed 04.02.15] ⟨http://www.dlight.com/solar-lighting-products/multifunction/dlight-s300/⟩.
35. International Rescue Committee (IRC). Women's Protection and Empowerment Unit (WPEU). Solar light selection report: Port-au-Prince Haiti. 2013 Unpublished program report.
36. SAS software. Version 9.3 (Windows). Cary, NC: SAS Institute Inc.; 2012. [Computer Software]
37. Cayemittes, M.; Busangu, MF.; Bizimana, JD., et al. Haïti, 2012. Calverton, Maryland, USA: MSPP, IHE Et ICF International; 2013. Enquête Mortalité, Morbidité et Utilisation des Services.
38. International Organization for Migration (IOM). DTM v.2 30 July 2013, Bing maps Aerial - ©2010 DigitalGlobe © GeoEye 2013 © Microsoft Corporation. 2013 [accessed 30.07.13] ⟨http://iomhaitidataportal.info/dtm/index2.aspx⟩.
39. Kish L. A procedure for objective respondent selection within the household. J. Am. Stat. Assoc. 1949; 44(247):380–387. http://dx.doi.org/10.1080/01621459.1949.10483314.
40. Kleinbaum, D.; Klein, M. Logistic regression: a self-learning text. 3rd. New York: Springer; 2010.
41. Microsoft Microsoft. PowerPoint. Redmond, Washington: 2010. [Computer Software]
42. R Core Team, R. A language and environment for statistical computing. Vienna, Austria: R foundation for statistical computing; 2014. URL://www.Rproject.org/. [Computer Software]
43. Therneau T. A Package for Survival Analysis in S. R package version 2.37– 7.2014. 2014 (URL): ⟨http://CRAN.R-project.org/package=survival⟩. [Computer Software].
44. Peck MD, Kruger GE, van der Merwe AE, et al. Burns and fires from nonelectric domestic appliances in low and middle income countries Part I. The scope of the problem. Burns. 2008; 34(3):303–311. http://dx.doi.org/10.1016/j.burns.2007.08.014. [PubMed: 18206314]
45. Bauserman M, Hailey C, Gado J, et al. Determining the utility and durability of medical equipment donated to a rural clinic in a low-income country. Int. Health. 2014 http://dx.doi.org/10.1093/inthealth/ihu091.
46. Masta W, Masta M. The gender, poverty, and energy nexus in Zimbabwe: The case of Gweru Urban and Shurugwi communal and resettlement areas. Br. J. Adv. Acad. Res. 2014; 3(1):1–25.

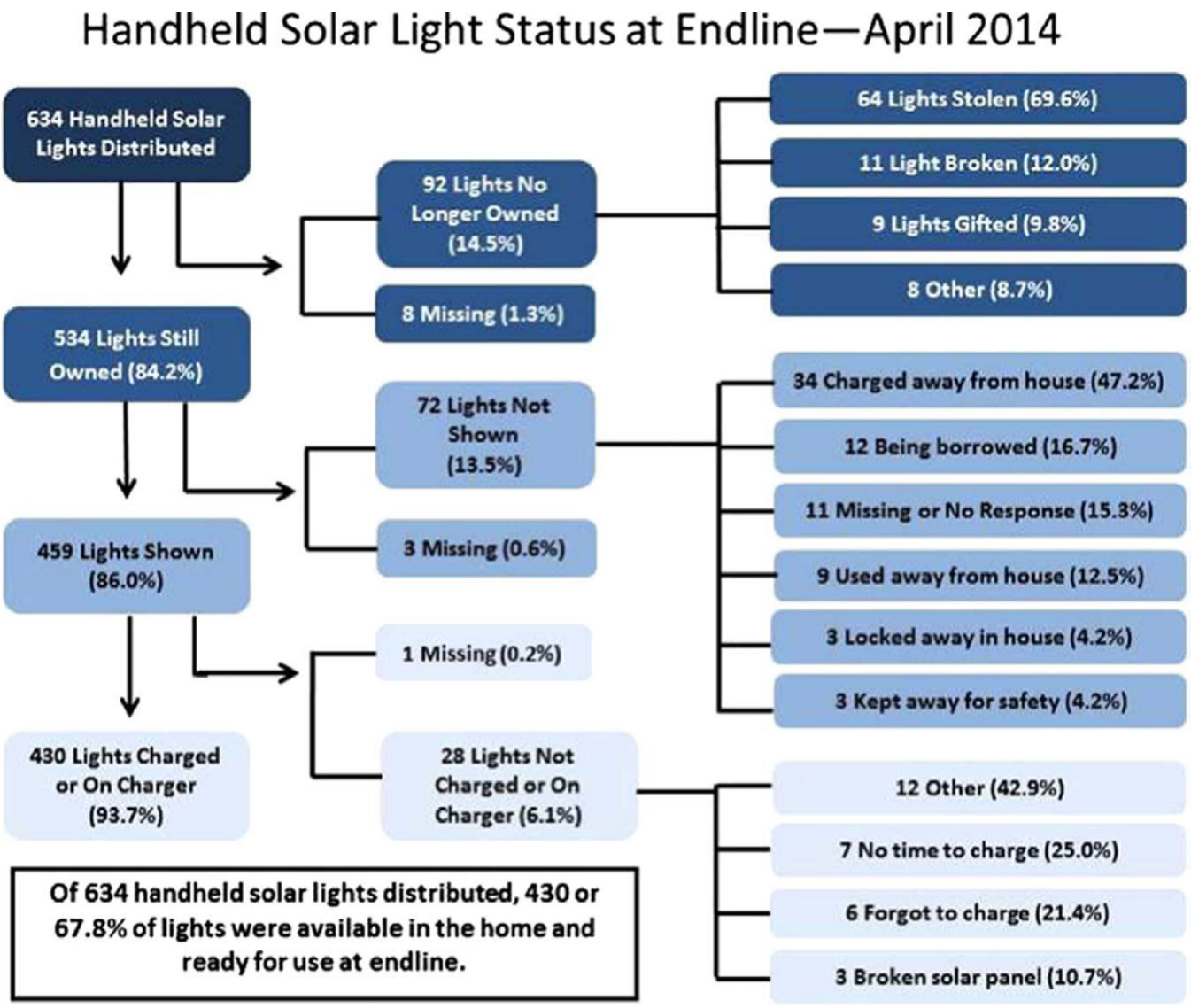
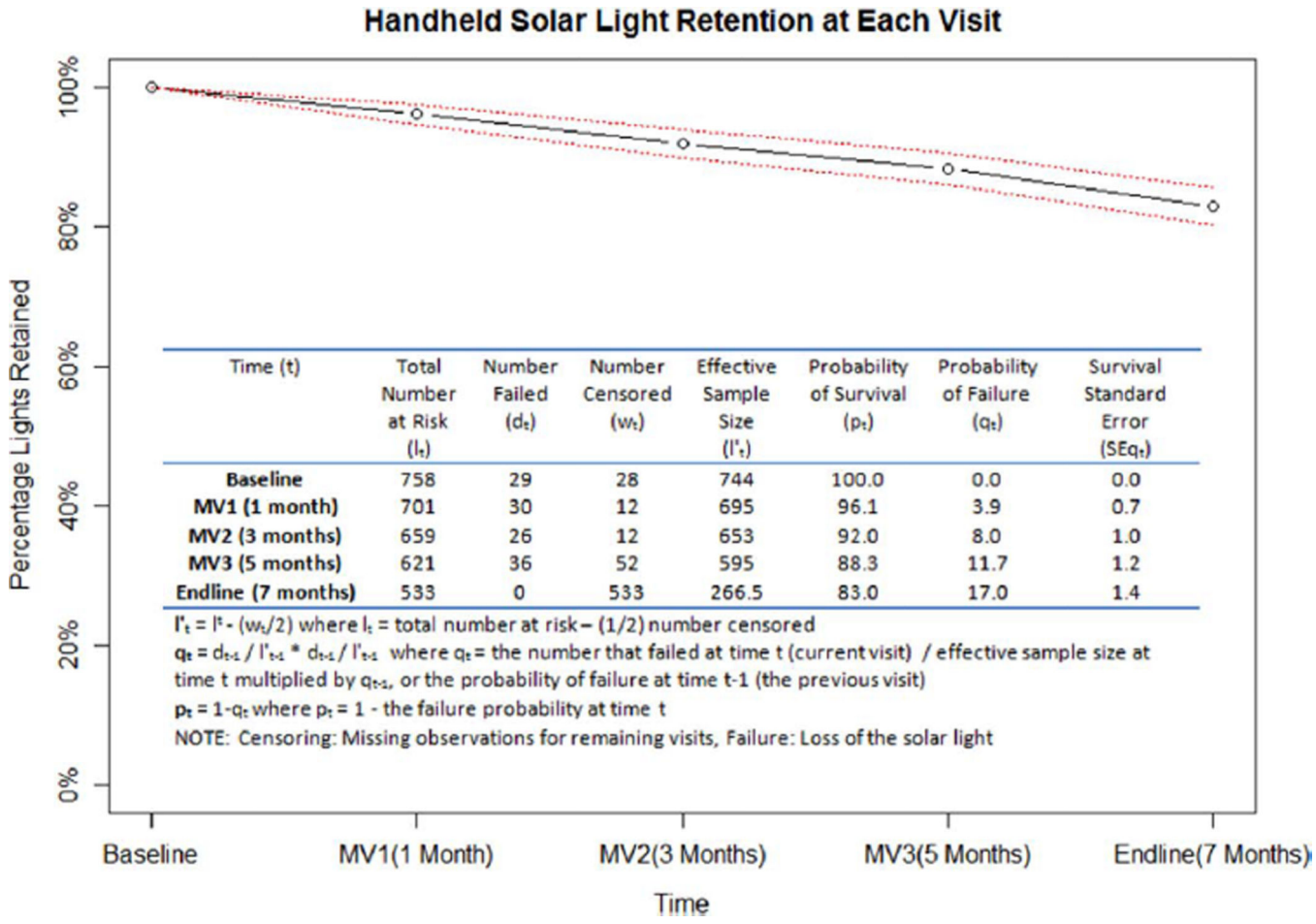


Fig. 1.
Handheld solar light status at endline in two camps in Haiti.



Time (t)	Total Number at Risk (l_t)	Number Failed (d_t)	Number Censored (w_t)	Effective Sample Size (l'_t)	Probability of Survival (p_t)	Probability of Failure (q_t)	Survival Standard Error (SEq_t)
Baseline	758	29	28	744	100.0	0.0	0.0
MV1 (1 month)	701	30	12	695	96.1	3.9	0.7
MV2 (3 months)	659	26	12	653	92.0	8.0	1.0
MV3 (5 months)	621	36	52	595	88.3	11.7	1.2
Endline (7 months)	533	0	533	266.5	83.0	17.0	1.4

$l'_t = l^t - (w_t/2)$ where l_t = total number at risk – (1/2) number censored

$q_t = d_{t-1} / l'_{t-1} * d_{t-1} / l'_{t-1}$ where q_t = the number that failed at time t (current visit) / effective sample size at time t multiplied by q_{t-1}, or the probability of failure at time t-1 (the previous visit)

$p_t = 1-q_t$ where p_t = 1 - the failure probability at time t

NOTE: Censoring: Missing observations for remaining visits, Failure: Loss of the solar light

Fig. 2.

Life-table survival estimates of handheld solar light retention among females aged ≥14 years in two camps in Haiti with 95% confidence intervals.

Int J Disaster Risk Reduct. Author manuscript; available in PMC 2016 September 01.

Table 1

Endline demographic characteristics among females age ≥ 14 years in two camps in Haiti.

	Total (N = 634)		Camp Sinai (n = 271)		Camp Toto (n = 363)		
Characteristic	**N**	**%**	**N**	**%**	**N**	**%**	**p-value[a]**
Age of selected female							
Average (SE)	31.1	0.5[b]	30.4	0.7	31.6	0.6	0.184
Education of selected female							<0.001[c]
No school	59	9.3	35	12.9	24	6.6	
Some primary level	193	30.4	102	37.6	91	25.1	
Some high school level	356	56.2	129	47.6	227	62.5	
Vocational, Literacy, College	23	3.7	5	1.9	18	5.0	
Don't know or no response	3	0.5	0	0	3	0.9	
Number of Household members							
Average (SE)	4.2	0.1[b]	3.9	0.1	4.4	0.1	<0.001
Time in camp (years)							
Average (SE)	3.6	0.0[b]	3.7	0.1	3.5	0.1	0.001

[a] Chi square p-value when categorical and *t* test statistic p-value when continuous for camp comparisons

[b] Standard Error of the mean

[c] Fischer's Exact tests were done

Table 2

Baseline and endline comparison of night-time activities among females age ≥ 14 years with repeated measures in two camps in Haiti.

Camp Sinai (N = 237)	Baseline (% yes)	Endline (% yes)	Odds Ratio (CI)	p-value
Reasons for going out at night in the last week:				
Personal reasons (e.g., using the latrine)	66.7	90.4	4.54 (2.06, 10.01)	<0.001
Religious purposes (e.g., attending church)	50.0	53.0	1.05 (0.59, 1.90)	0.839
Needed to buy water/food/gas or other stuff	27.9	71.1	5.33 (3.36, 8.46)	<0.001
Social activities (e.g., visiting friends, or attending outdoor/cultural activity)	24.2	25.3	1.04 (0.50, 2.13)	0.924
Work (e.g., selling)	16.7	9.64	0.55 (0.22, 1.38)	0.203
Camp Toto (N = 316)	Baseline (% yes)	Endline (% yes)	Odds Ratio (CI)	p-value
Reasons for going out at night in the last week:				
Personal reasons (e.g., using the latrine)	68.2	77.4	1.58 (0.86, 2.90)	0.144
Religious purposes (e.g., attending church)	41.4	50.9	1.45 (0.83, 2.54)	0.195
Social activities (e.g., visiting friends, or attending outdoor/cultural activity)	36.8	27.4	0.71 (0.37, 1.29)	0.259
Needed to buy water/food/gas or other stuff	28.5	70.8	5.52 (3.53, 8.62)	<0.001
Work (e.g., selling)	20.5	20.8	1.00 (0.50, 1.97)	0.991

Table 3

Baseline and endline comparison of sources of light use among females age ≥ 14 years with repeated measures in two camps in Haiti.

Camp Sinai (N = 237)	Baseline (% yes)	Endline (% yes)	Odds Ratio (CI)	p-value
Sources of lighting INSIDE the house				
Phone	59.6	57.9	0.93 (0.66, 1.30)	0.668
Candle	88.0	31.1	0.06 (0.04, 0.10)	<0.001
Flashlight	11.5	8.1	0.68 (0.37, 1.22)	0.196
Gas Lamp	18.0	7.7	0.38 (0.22, 0.66)	<0.001
Sources of lighting OUTSIDE the house				
Phone	40.8	50.6	1.48 (1.04, 2.12)	0.030
Candle	23.9	13.6	0.50 (0.31, 0.81)	0.005
Flashlight	9.2	7.2	0.77 (0.41, 1.46)	0.419
Gas Lamp	6.0	4.7	0.77 (0.34, 1.70)	0.515
Camp Toto (N = 316)	Baseline (% yes)	Endline (% yes)	Odds Ratio (CI)	p-value
Sources of lighting INSIDE the house				
Phone	71.9	63.0	0.67 (0.49, 0.91)	0.010
Candle	56.6	20.3	0.20 (0.14, 0.27)	<0.001
Flashlight	23.6	14.2	0.54 (0.39, 0.75)	<0.001
Gas Lamp	47.9	25.0	0.36 (0.28, 0.47)	<0.001
Sources of lighting OUTSIDE the house				
Phone	56.4	53.5	0.89 (0.66, 1.20)	0.447
Candle	22.8	9.8	0.37 (0.23, 0.58)	<0.001
Flashlight	19.9	12.7	0.59 (0.42, 0.84)	0.004
Gas Lamp	19.5	7.9	0.36 (0.23, 0.55)	<0.001

Table 4

Endline results of handheld solar light maintenance among females age ≥ 14 years in two camps in Haiti.

	Total (N = 634)		Camp Sinai (n = 271)		Camp Toto (n = 363)		
Characteristic	**N**	**%**	**N**	**%**	**N**	**%**	**p-value[a]**
Length of time to charge the solar light (in hours)							
Average (SE)	5.3	0.2[b]	5.0	0.2	5.7	0.2	0.035
Light/panel/cable has broken							0.033[c]
Nothing broke	483	76.2	213	78.6	270	74.4	
Only Lamp, Panel, or Cable	79	12.5	21	7.9	58	15.9	
Panel and cable	4	0.6	2	0.7	2	0.6	
Light and panel	2	0.3	1	0.4	1	0.3	
No response or don't Know	4	0.7	2	0.7	2	0.6	
Missing	62	9.8	32	11.8	30	8.3	
	Total (N = 89)		Camp Sinai (n = 26)		Camp Toto (n = 63)		
Light/panel/cable has been fixed							0.285
No - still broken	23	25.8	2	7.7	21	33.3	
No - still works	11	12.4	2	7.7	9	14.3	
Yes	18	20.2	0	0.0	18	28.6	
Don't know	1	1.1	1	3.9	0	0.0	
Missing	35	39.3	21	80.8	14	22.2	
	Total (N = 18)		Camp Sinai (n = 0)		Camp Toto (n = 18)		
Average time taken to fix the solar light							–
Less than 1 d	3	16.7	0	0.0	3	16.7	
1 d or more	7	38.9	0	0.0	7	38.9	
Missing	8	44.4	0	0.0	8	44.4	

NOTE: An initial visit was conducted at week one following light distribution to pilot the survey and replace any non-functioning handheld solar lights.

[a] Chi square p-value when categorical, *t* test statistic p-value when continuous;

[b] Standard Error of the Mean.

[c] Fischer's Exact tests were done