Biosafety Competencies in Developing Countries: The Role of Universities

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Abstract

With the objective of strengthening biosafety capacities in Honduras, a technical cooperation program has been established with the School of Microbiology, National Autonomous University of Honduras, where most of the country’s infectious disease research and teaching is done. To complete a 2-year cooperation cycle, two significant activities took place in May 2010: the first National Biosafety Meeting in which a Knowledge and Perceptions survey was administered to participants; and secondly, standardized biosafety capacity assessments of several laboratories. Following Emory University Onsite Biosafety Training Program guidelines, assessments evaluated four primary biosafety controls: engineering; personal protective equipment (PPE); standard operating procedures (SOPs); and administrative controls. This technical cooperation program has been successful in revitalizing the school’s biosafety committee and garnering institutional interest. The survey revealed that 57% of respondents did not feel safe in their work environment and that 31% were aware of laboratory-acquired infections in their workplace. Assessments of 12 laboratories showed an overall biosafety grade of 72% and the following specific grades by control: engineering, 73%; PPE, 81%; SOPs, 68%; and administrative controls, 66%. Research laboratories scored consistently higher than their teaching counterparts. Recommendations stemming from these findings have been integrated into the school’s strategic plan. Among other positive changes, the university has allocated a space for a Biosafety Training Center to be launched in the near future. Other efforts towards strengthening biosafety are also underway within the Honduran Ministry of Health. The time is right for Honduras to coordinate efforts leading to the establishment of a nationwide biosafety culture.

Introduction

Biosafety and biosecurity are nowadays considered not only as sets of appropriate practices to be implemented in life sciences laboratories with the aim of protecting personnel and the environment, but also as core values of rigorous, ethical science as well as inextricable components of international research cooperation. Several factors have converged to generate this increasing recognition and the current momentum experienced in the field of biosafety sciences.

Speed and volume of travel and commerce, for example, permit the relative ease with which infectious agents can be dispersed (with humans, foodstuffs, or animals) from one side of the planet to the next in a matter of hours (Scotto, 2011). In fact, over the last few years, the world has been preoccupied with the emergence and re-emergence of pathogens and the possibility of pandemics of devastating consequences (IOM & NRC, 2009). This continuing threat has promoted a considerable expansion of transnational scientific and public health networks that permit unprecedented collaboration based on knowledge and technology transfer as well as sharing of pathogens. The latter introduces a new dimension to the globalization of infectious diseases, as these pathogens may find a way out from laboratories. Among other well-known examples, it has been recently hypothesized that laboratory errors may have led to the escape of the 2009 strain of H1N1 influenza A virus from a laboratory with its subsequent re-assortment and spread in the human population (Gibbs et al., 2009).

Similarly, along with current biotechnology advances that permit the production of living modified organisms, the need has arisen to formulate and implement regulations that can be adapted across countries and regions to minimize potential risks that such organisms may pose to ecosystems and human as well as animal health (McLean et al., 2002).

Furthermore, past experiences with the misuse and intentional release of dangerous pathogens have created the need for global-scale efforts leading to the integration of biosafety sciences with biosecurity principles and the advent of the concept of biorisk management (Rudelsheim, 2008). The threat of bioterrorism, however small, carries the potential for immeasurable consequences that transcend public health and endangers global economy and peace. In fact, biosafety and biosecurity have been proposed as essential tools for the stability and development of nations and even entire geopolitical regions (Chua et al., 2009; Nayef et al., 2007; Salerno et al., 2007). All of these factors underscore the urgency of global cooperation and, fortunately, capacity.
strengthening for biosafety and biosecurity are not considered in isolation anymore but as “elements of a greater framework of strengthening global health and security” (IFBA, 2011).

A variety of frameworks and guidelines have been created to assess and strengthen capacities within public health networks and laboratories for they are invested with leadership functions in the event of pandemic containment and bioterrorism readiness (Delany et al., 2011; Marshall et al., 2010). However, even within public health laboratory systems, there exist multiple partners influencing either upstream preparation or downstream decisions and timely actions. Among such partners are the educational institutions that prepare the professionals that would become regulators, leaders, or policymakers. Universities and colleges can and do play a fundamental role in education and training. In this sense, academic laboratories, whether engaged in teaching, research, or both are key stakeholders in promoting a biosafety culture (Lucero et al., 2005). In fact, a systems approach that includes teaching and training is essential to the continual improvement of biorisk management at any level (CEN, 2008).

In developing countries where, despite current efforts, many weaknesses still exist in regard to biosafety and biosecurity practices (Astuto-Gribble et al., 2009), the need for technical cooperation is more pressing than ever.

Honduras is an example of a developing country in which infectious diseases are a leading cause of morbidity and mortality. In addition to the scourge of ancient diseases (many of them among the so-called neglected tropical diseases), the country periodically faces the devastating effects of vector-borne diseases such as Dengue and continues to struggle with one of the highest HIV/AIDS rates in Latin America (with the ensuing increase in tuberculosis cases) (PAHO, 2007; UNAIDS, 2010; United Nations System in Honduras, 2010). Moreover, emerging pathogens such as influenza A H1N1 have made their way into the country underscoring the fact that infectious disease outbreaks know no borders and countries must tackle these threats together in order for containment to be effective. As in other countries where the fight against infectious diseases is an ongoing battle, clinical laboratories in Honduras are at the heart of public health activities. Therefore, laboratory personnel at all levels, as well as other health professionals and scientists, must be endowed with the knowledge and skills to work with infectious agents in a safe and secure manner.

In Honduras many of these personnel are trained at the School of Microbiology in the National Autonomous University of Honduras (UNAH), and we have established a technical cooperation program to strengthen research capacity and biosafety practices at UNAH. This article reports and analyzes the outcome and impact of the first external biosafety evaluation undertaken at the School of Microbiology, UNAH, where most of the infectious disease teaching and research in the country are done.

Methodology

Capacity-building Program

In partnership with the School of Microbiology, UNAH, a program dedicated to increasing competencies in biosafety began in 2008. Accordingly, a series of knowledge transfer activities and training sessions have been undertaken. International biosafety experts have visited the country and delivered conferences and skill-based workshops for laboratory-associated personnel from both UNAH and other stakeholders. Additionally, Honduran key personnel have attended international conferences and courses and, in turn, disseminated their knowledge to others upon return. Capacity-building at the School of Microbiology has also included the implementation of a fully equipped biosafety level 2 (BSL-2) research laboratory, the acquisition of biosafety materials and supplies, as well as the facilitation of locally produced printed resources. A key component of the program has been revitalizing the school’s biosafety committee.

To complete a 2-year cooperation cycle, in May 2010 two significant activities took place over a 2-week period: the first National Biosafety Meeting in which a Knowledge and Perceptions survey was undertaken; and secondly, a standardized assessment of laboratory biosafety capacity at the School of Microbiology. These activities are described in detail below.

Knowledge and Perceptions Survey

The First National Biosafety Meeting, a full-day meeting that took place in Tegucigalpa on May 17, was attended by a multidisciplinary audience from several institutions. During this meeting a random sample of participants was surveyed on their knowledge and perception about biosafety. The survey was administered utilizing the audience response system ARS SNAP!™ (Audience Response Systems, Inc., Evansville, Indiana, USA). Multiple-choice questions were included within PowerPoint® presentations throughout the day. Participants utilized keypads to report their answers and data were generated simultaneously by ARS SNAP!™ software. Questions ranged from descriptions of their workplace, prior training, knowledge of national regulations, risk perception and the workplace, and biosafety-specific knowledge.

Biosafety Capacity Assessment

Biosafety capacity assessment visits were conducted in various BSL-2 research and undergraduate teaching laboratories at the School of Microbiology, UNAH. These assessments followed the terms of reference of the
Emory University Onsite Biosafety Training Program (www.sph.emory.edu/CPHPR/biosafetytraining/onsite.html). ONSITE's data-collecting forms "Assessing Biosafety Programs: Evaluating Laboratory Capacity for Handling Infectious Pathogens" were utilized to conduct the assessments. Forms with detailed information are available upon request.

Four primary controls for biosafety were assessed in each laboratory: engineering; PPE; SOPs; and administrative controls. The assessment of each primary control comprised the evaluation of a defined set of characteristics as depicted in Table 1. The assessment was a two-step process. First, the consultant performed an "external evaluation" while visiting the laboratory, asking a series of standardized questions to the laboratory's leadership (course instructor, manager, or primary investigator) and/or the staff, as well as by direct observations of the laboratory environment and records. Second, the consultant separately interviewed the lab manager or primary investigator and a member of the staff representing the workforce so they could provide their own assessment or "internal evaluation." The assessment was done by means of a standardized scoring system using the scale depicted in Table 2. Briefly, percentages or letter grades were assigned to each characteristic within the primary controls. These letter grades were converted to numerical values and added together to average the quality points obtained for each control. Primary control averages would then be added together to generate a final percentage and letter grade for the laboratory. Qualitative interpretations of the final scores can be seen in Table 2. It was agreed that a laboratory would have to achieve an overall 85% score to be designated as having attained a good level of biosafety.

In addition to the laboratory assessments, an inventory of pathogens and biological samples was requested from each lab and an appraisal was conducted of the strengths and improvement opportunities within the School of Microbiology and the university as a whole.

**Results**

**Capacity Building**

The overall program has been very successful in revitalizing the biosafety committee and garnering political will from UNAH's academic administration. Established since 1994, the committee operated at the school level only, with virtually no budget and without an institutional policy to endorse its activities. Its work revolved around establishing good microbiological practices at the teaching laboratories, but since no biosafety training was strictly mandatory for students, staff, or faculty members, the committee had a limited influence over the overall safety practices at the school. Currently, the biosafety committee is highly active and has become a central aspect of the school's academic life. In particular, cleaning staff and laboratory technicians have re-

<table>
<thead>
<tr>
<th>The Primary Controls of Biosafety</th>
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<tbody>
<tr>
<td><strong>Engineering Controls</strong></td>
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<td>-----------------------------------</td>
</tr>
<tr>
<td>Electrical</td>
</tr>
<tr>
<td>Security systems</td>
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<tr>
<td>HVAC systems</td>
</tr>
<tr>
<td>Alarm systems</td>
</tr>
<tr>
<td>Physical structure</td>
</tr>
<tr>
<td>Equipment safety</td>
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<tr>
<td>Quality of equipment</td>
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<tr>
<td>Equipment dependability</td>
</tr>
<tr>
<td>Maintenance of equipment</td>
</tr>
<tr>
<td>Maintenance of physical structure</td>
</tr>
</tbody>
</table>

*Following the guidelines of Emory University Onsite Biosafety Training Program*
ceived significant attention and have participated in various training workshops as well as have been provided with PPE to reduce exposures. A biosafety officer is currently available to students, faculty members, and researchers for consultation on biosafety matters. Importantly, the biosafety officer works together with graduate and undergraduate students engaged in research work to make sure they understand and mitigate the risks associated with their laboratory investigations. Special attention has been given to handling and transporting infectious specimens and other biohazards. In terms of biosafety manuals, although the school has been utilizing the 2004 WHO’s biosafety guidelines (WHO, 2004), it was felt that a locally produced biosafety manual would be also appropriate. Thus, the first Biosafety Manual for the school was published in 2009 and is now widely used among faculty and students.

A major accomplishment of this cooperation program is the implementation of a fully equipped BSL-2 research laboratory named “The Teasdale-Corti Laboratory” in honor of the specific funding program through which the collaboration was established (Figure 1). This entailed extensive renovations of existing spaces and the acquisition of a considerable amount of small and large equipment and supplies (from biohazard bags to autoclaves and other materials, to biosafety cabinets [BSCs] and a fume hood). Also, through small research and teaching grants for faculty members, courses such as quality assurance in the laboratory have been held, teaching laboratories have been renovated, and a significant amount of biosafety materials and supplies has been purchased (including signage, gloves, biohazards disposal materials, etc.). Additionally, an electronic publication frequently showcasing articles on biosafety has been supported (www.revistadelmicrobiologo.org). Experts from the Mexican Association of Biosafety (Amexbio) and Emory University have visited the country and delivered conferences and workshops, and training has been secured for Honduran key personnel in Mexico, Canada, and the United States. More details about these and other capacity-strengthening activities in Honduras can be found at the project’s web site at www.brocku.ca/globalhealth.

### Inventory of Pathogens

Teaching and research, the two main activities at the School of Microbiology, entail the determination and/or culture and isolation of human pathogens. A complete inventory of organisms was not available until the biosafety assessment was undertaken. Universally, inventoried pathogens were categorized as Risk Group 2 organisms (WHO, 2004). Among those pathogens, however, cultures of the fungal species *Histoplasma capsulatum*, *Blastomyces dermatitidis*, *Coccidioides immitis*, and *Paracoccidioides brasiliensis*, which are classified as Risk Group 3 in other countries (Canada DOJ, 2009), were routinely worked with under open bench conditions.

### Knowledge and Perceptions Survey

The First National Meeting was a tremendous success, with 136 people in attendance from various institutions ranging from universities to public health and veterinary laboratories. Eighty-two percent of the participants were women, 38% were either undergraduate or graduate students, 46% were professionals, and 16% were administrators. From this audience, 30 persons were randomly selected to respond to the Knowledge and Perceptions (K&P) survey and to biosafety-specific

### Table 2

**Scoring system used for biosafety evaluation.**

<table>
<thead>
<tr>
<th>Score (%)</th>
<th>Grade</th>
<th>Quality Points</th>
<th>Qualitative Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>100-95</td>
<td>A</td>
<td>4.00</td>
<td>Excellent</td>
</tr>
<tr>
<td>90-94</td>
<td>A-</td>
<td>3.66</td>
<td>Good</td>
</tr>
<tr>
<td>87-89</td>
<td>B+</td>
<td>3.33</td>
<td>Fair</td>
</tr>
<tr>
<td>86-84</td>
<td>B</td>
<td>3.00</td>
<td>Fair</td>
</tr>
<tr>
<td>83-80</td>
<td>B-</td>
<td>2.66</td>
<td>Poor</td>
</tr>
<tr>
<td>79-77</td>
<td>C+</td>
<td>2.33</td>
<td>Poor</td>
</tr>
<tr>
<td>76-74</td>
<td>C</td>
<td>2.00</td>
<td>Poor</td>
</tr>
<tr>
<td>73-70</td>
<td>C-</td>
<td>1.66</td>
<td>Poor</td>
</tr>
<tr>
<td>69-67</td>
<td>D+</td>
<td>1.33</td>
<td>Poor</td>
</tr>
<tr>
<td>66-64</td>
<td>D</td>
<td>1.00</td>
<td>Unacceptable</td>
</tr>
<tr>
<td>63-60</td>
<td>D-</td>
<td>0.66</td>
<td>Unacceptable</td>
</tr>
<tr>
<td>59-0</td>
<td>F</td>
<td>0.00</td>
<td>Unacceptable</td>
</tr>
</tbody>
</table>
questions utilizing the audience response system described above.

Table 3 shows a self-description of the participants (questions 1-3); their familiarity with workplace or national regulations as it pertains to workplace safety biosafety or hazardous waste management (questions 4-6); their perception of occupational risk (questions 7-8); and their opinion on the importance of biosafety training (questions 9-10). It is worth noting that the majority of people who responded that they worked in a BSL-1 laboratory actually worked in a BSL-2 facility. In regard to training, almost half of the respondents did not attend biosafety instruction in the past year, but all expressed interest in receiving different formats of training. More than half of the participants (57%) felt they were not protected in their workplace and 31% were aware of laboratory-acquired infections in their workplace. The corresponding question to the latter finding implied the respondent’s lifetime experience and did not require further details from the participant.

Table 4 shows biosafety-specific knowledge of the polled individuals. As questions were posed in the context of a talk related to the topic, the level of knowledge was considerably high. Very importantly, people felt a strong connection between science and safety and were fairly conscious that human behavior is the key to the safe handling of biological hazards.

Biosafety Capacity Assessment of Teaching and Research Laboratories

Laboratory assessments were undertaken in 12 out of 17 existing laboratories. Of the 12 assessed, five were mainly dedicated to research and seven to teaching. One laboratory (labeled number 2 on the figures) did not have permanent staff to be interviewed, so the average was adjusted accordingly.

Interviews took place after several activities for biosafety strengthening had taken place. In particular, the consultant facilitated some workshops and gave several talks on BSL-2 practices and also on the role of human behavior in laboratory safety. This allowed for a better understanding by the leadership and staff of the concepts and terminology used for the assessments. Moreover, since the interviews to obtain the internal assessments by the leadership and staff were face-to-face with the consultant, there was ample opportunity for further clarification.

The average grade for all 12 laboratories was 72% (SD = 5%). For each biosafety control, the average results were: engineering, 73%; PPE, 81%; SOPs, 68%; and administrative controls, 66%. Figure 2 shows the average percentages for each laboratory by biosafety control. Laboratories numbered 1-5 were dedicated to research whereas laboratories 6-12 to teaching. Considering the thresholds explained above, laboratories were universally below a good level of biosafety (<85%) but above the unacceptable level (≤59%).

Figure 3 displays assessments for laboratories showing the scores estimated for leadership, staff, and the consultant. Notwithstanding the training occurring around the interviews, there was a difference in the external assessment (i.e., consultant) as compared to the internal one (leadership and staff).

Research Versus Teaching Laboratories

When categorized as a research or teaching laboratory, interesting differences were revealed. Research laboratories scored consistently higher in every respect.
### Table 3
Self-description of Participants: Knowledge on regulations and perceptions about occupational risk and biosafety training among participants to the First National Biosafety Meeting, Honduras, May 17, 2010 (n = 30).

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer Options and % of Responses</th>
<th>Comment/Correct Answer</th>
</tr>
</thead>
</table>
| 1. In what biosafety containment level (BSL) do you work?                | BSL-1: 30%  
BSL-2: 26%  
BSL-3: 0%  
Not applicable: 30%  
I don’t know: 15%                                                                                                                                                                                                 | The majority of participants actually worked for clinical laboratories where biological specimens and laboratory cultures are handled, so they would technically work in BSL-2. |
| 2. In how many biosafety talks, trainings, or courses have you participated in the last year? | 0: 43%  
1: 39%  
2: 4%  
3: 9%  
4: 4%                                                                                                                                                                                                                                   |                                                                                                                                                                           |
| 3. In what type of biosafety education/training would you be interested in participating annually? | One or two short talks or seminars: 30%  
A short course <20 hours: 30%  
An intensive course 1-2 weeks: 20%  
A 100-hour diploma course: 20%  
I don’t know: 0%                                                                                                                                                                                   |                                                                                                                                                                           |
| 4. How well do you know the occupational health and safety policy of your workplace? | Very well: 4%  
Not well but there is one: 54%  
I know there is a policy but I have never read it: 38%  
I believe there is no such policy in my workplace: 4%                                                                                                                                                 | Most workplaces in Honduras do have occupational health policies as the law mandates them to have them in place.                                                                                       |
| 5. Are you aware of the existence of biosafety guidelines or regulations in your workplace? | Yes: 72%  
No: 28%                                                                                                                                                                                                                                         |                                                                                                                                                                           |
| 6. Are you aware if there is a law in Honduras to regulate hazardous biomedical and infectious waste? | Yes: 37%  
No: 63%                                                                                                                                                                                                                                         | In July 2008, the Honduran government through the Ministry of Health approved legislation for the appropriate handling and disposal of hazardous waste. It became effective on February 28, 2009 (Honduras Jurisprudence and Legislation, 2008). |
| 7. How protected do you feel from acquiring an infection while performing your job? | Protected: 37%  
Unprotected: 56%  
I don’t know: 7%  
Not applicable: 0%                                                                                                                                                                                                                   |                                                                                                                                                                           |
| 8. Are you aware of any laboratory-acquired infection in your workplace? | Yes: 31%  
No: 69%  
Not applicable: 0%                                                                                                                                                                                                                     |                                                                                                                                                                           |
| 9. In your opinion, which of the following is the single most important element of a biosafety program? | Personal protective equipment: 12%  
Training: 60%  
Equipment and physical facilities: 8%  
Regulations: 20%  
I don’t know: 0%                                                                                                                                                                   | Most experts would agree that behavior and training are the single most important elements (Kaufman et al., 2007).                                                                                  |
| 10. In your opinion, how important is biosafety training as part of the overall best practices and quality assurance of your laboratory or workplace? | Very important: 97%  
Moderately important: 3%  
Not too important: 0%  
It doesn’t make any difference: 0%  
I don’t know: 0%                                                                                                                                                                      |                                                                                                                                                                           |

BSL: biosafety level
Table 4
Biosafety-specific knowledge displayed by participants at the First
National Biosafety Meeting, Honduras, May 17, 2010 (n = 30).

<table>
<thead>
<tr>
<th>Question</th>
<th>Responses in % (Correct response shown in bold)</th>
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| 1. How strong do you believe is the relationship between science and safety? | Very strong: 80%  
Moderate: 20%  
Not much: 0%  
No relation: 0%  
I don’t know: 0% |
| 2. Having a biosafety manual guarantees good laboratory practices.       | Yes: 32%  
No: 68% |
| 3. How important is having a medical surveillance program for minimizing risks? | Very important: 100%  
Moderately important: 0%  
Not too important: 0%  
It doesn’t make any difference: 0%  
I don’t know: 0% |
| 4. Who is responsible for the adherence to biosafety regulations in the laboratory? | Administrators: 0%  
Biosafety Officer: 12%  
Lab Director: 4%  
Lab Technicians: 0%  
Everybody: 84% |
| 5. Besides knowledge and resources, what is another factor necessary to ensure sustainable behavior? | Understanding risks and benefits of change: 88%  
Regulations and laws: 12%  
I don’t know: 0% |
| 6. How much weight does human behavior bear on expected results?         | Considerable weight: 100%  
Moderate: 0%  
Not much: 0%  
None: 0%  
I don’t know: 0% |
| 7. The following is an example of personal protective equipment:          | Biosafety cabinet: 11%  
Gloves: 82%  
Decontamination procedures: 7%  
Standard operating procedures validation: 0% |
| 8. The following is an example of biosafety administrative control:       | Biosafety cabinet: 4%  
Gloves: 4%  
Decontamination procedures: 19%  
Standard operating procedures validation: 73% |
| 9. True or False: All work in a BSL-2 laboratory must be done inside a biosafety cabinet. | True: 26%  
False: 74% |
| 10. A sophisticated facility with strong engineering controls ensures protection in the daily laboratory work. | Yes: 0%  
No: 100% |

compared to their teaching counterparts, for an overall grade of 77% versus 68%, respectively. When investigating the differences, it was found that results were fairly similar in the administrative controls (68% vs. 65%) but differed remarkably in the remaining three controls (Figure 4).

All research laboratories were collaborating with international partners, which provided funding for renovations and upgrades, purchase of new equipment (including BSCs), and sufficient supply of PPE. As well, due to the nature of the investigations carried out, research laboratories had a good collection of SOPs and laboratory techniques. The teaching laboratories, on the other hand, relied entirely on the institution’s resources. For example, none of the teaching laboratories had BSCs, some lacked appropriate storage spaces for pathogen collections, and all struggled with securing a steady supply of PPE and appropriate hazardous waste disposal materials.

**Overall Assessment by Biosafety Control**

**Engineering Controls:** As seen in Table 1, the engineering assessment entailed appraisal of structural aspects beyond the power of individual laboratories (such as electricity and facilities management) as well as laboratory equipment and maintenance. Frequent power
Figure 2
Biosafety scores by each of the four controls for 12 university laboratories in Honduras.

*Research labs: 1-5; teaching labs: 6-12

Figure 3
Comparison of average biosafety scores assigned by staff, leadership, and consultant for 12 university laboratories in Honduras.

*Research labs: 1-5; teaching labs: 6-12; †There is no permanent staff in lab 2
outages occur in the city, and with the lack of emergency power generators at the institution, laboratories are left without power on a regular basis. Also, facilities maintenance was reported to be slow and unreliable and there were persistent problems such as roof leakage and general physical upkeep. Although these situations were similar for both research and teaching laboratories, due to external funding availability, the former were able to have better working conditions (although several principal investigators reported resorting to personal funding to install locks, paint, or have equipment repaired). Most teaching laboratories lacked air conditioning, which forced staff to work with open windows (often without screens).

**PPE Controls:** Unavailability of disposable gloves was a prominent problem for the teaching laboratories and students were required to supply their own gloves during laboratory practices. It was noted that disposable facemasks were often cited as being used by lab technicians and students when working with clinical samples and bacterial cultures for splash protection as well as to block odors. N95 disposable respirators were used in some research laboratories, although the work being done was not deemed to require respiratory protection. It is also worth mentioning that laboratory coats were consistently worn outside the BSL-2 laboratories. This was especially true for students, who were observed wearing their laboratory coats everywhere, including off campus. Also, as no laundry facilities are available at the university, all personnel reported bringing their lab coats home to launder. Additionally, although wearing open-toe shoes in the BSL-2 labs was discouraged, not everybody complied with this safety practice.

**SOP Controls:** Research laboratories had binders with lab techniques and teaching laboratories had manuals to conduct practical sessions. However, neither research nor teaching laboratories had available SOPs nor manuals for good microbiological techniques, including house rules (laboratory code of conduct), safe handling of specimens, spill containment procedures, etc. No SOPs were available for autoclaving, cleaning contaminated material, transporting biohazards from teaching laboratories to the autoclave room, disposing of biological specimens, etc. The lack of appropriate spaces for personnel to store and consume their food and to wash their utensils was revealed to be a serious problem during the onsite assessment. Food was sometimes stored in laboratory refrigerators and utensils washed in laboratory sinks (Figure 5).

**Administrative Controls:** As mentioned, at the time of the interviews no institutional biosafety guidelines and regulations existed at UNAH, and despite noble efforts from the biosafety committee members, there was no firm strategy to ensure full compliance with international guidelines. Most BSL-2 laboratories had a biohazard sign on the door, but the type of hazard and protection required were not specified. No laboratory kept records of incidents or accidents and many of the interviewees were not aware of the occurrence of laboratory-acquired infections. Similarly, medical surveillance protocols were
unheard of among interviewees, and, in some cases, their implementation was deemed unnecessary, as most pathogens with which they worked are endemic to the country. Emergency/contingency plans were non-existent at the local or institutional level. Importantly, cognitive training (e.g., seminars and talks) on biosafety was held with some regularity and most courses with a laboratory component had integrated one biosafety awareness session into their curriculum.

Based on all these findings, on October 2010, a full report was provided to the School of Microbiology and other senior administrators, including the Dean of Faculty of Sciences. The report contained a set of 20 recommendations as to how to strengthen biosafety capacities at the school so it could operate more safely, and in time, lead university-wide efforts. Additionally, each participating laboratory was provided with an individual report containing specific recommendations. Recognizing that attaining a sustainable higher level of biosafety requires collective ownership from all stakeholders, the biosafety committee conducted a detailed analysis of the report with staff and faculty members so together they could propose and be responsible for the achievement of common goals.

Institutional Response to the Assessment

Following the biosafety assessment and recommendations provided in 2010, the School of Microbiology has developed a strategic plan 2011-2014 and has taken immediate actions such as: strengthening the school’s biosafety committee; developing standard operating procedures SOPs; improving waste management (with the aid of the Swedish Cooperation); and holding students’ training and awareness events regularly. A follow-up assessment visit is planned for 2012. Additionally, the Faculty of Sciences has allocated physical space for a Biosafety Training Center, which will be managed by the biosafety committee. At the moment, the biosafety committee is drafting a work plan to launch the Center with a “train the trainers” component. At the same time it has recruited international experts to assist with developing a portfolio of courses and training opportunities for a wide array of professionals and students.

Discussion

The results of the survey—although lacking scientific validity—revealed important gaps in knowledge and training among the audience. Of special concern was that 31% of the participants reported knowing of a laboratory-acquired infection in their workplace. As mentioned, the corresponding question to this finding implied the respondent’s lifetime experience and did not require the participant to elaborate on his or her answer. Since clinical, teaching, or research laboratories in Honduras do not keep track of accidental exposure to pathogens, there is no available data to corroborate this finding. Therefore, it must be interpreted with caution. However, this finding alone merits an in-depth investigation and should prompt employers and laboratory managers to implement annual biosafety trainings as well as incident reporting and medical surveillance programs. Another important finding was that, unbeknownst to the majority of participants, since 2009 Honduras has had national regulations for the safe handling and disposal of hazardous waste (infectious, chemical, and radioactive) produced at medical facilities, clinical and forensic laboratories, blood banks, universities, funerary services, cemeteries, and others. According to the regulations, if hazardous waste cannot be rendered innocuous at the pri-
many facilities, sanitary pits would be made available at municipal land or public cemeteries. Naturally, compliance with these regulations will require certain conditions to be met such as having the knowledge and capacity (administrative, material, and human resources) at the primary facilities where waste is produced. These conditions are yet to be developed in most facilities in Honduras.

The findings from the capacity assessment of teaching and research laboratories at the School of Microbiology showed a fair degree of biosafety awareness among the interviewees and revealed excellent opportunities for improvement. For example, some laboratories were doing relatively well in terms of PPE and equipment controls as opposed to SOPs and administrative controls. Since writing and validating SOPs and implementing biosafety training and SOP compliance require less economic investment and more commitment and institutional support, leaders from participating laboratories were amenable to making short-term changes to increase biosafety in their laboratories and, by the same token, the security of the pathogens in the laboratories. One of the main recommendations stemming from the assessments was the articulation of contingency plans and emergency response strategies, with special attention to formulating SOPs for working in the laboratory under power outages, equipment breakdown, and PPE scarcity. Further, as the assessments performed with the Onsite program did not account for risk, laboratory leaders were also encouraged to conduct risk assessments to determine appropriate laboratory-specific levels of control and the ensuing risk management strategies.

The assessments also revealed striking differences between research and teaching laboratories. On one hand it was encouraging to see that research laboratories operating fairly independently from the institution, were well equipped and did not suffer from a serious lack of PPE. On the other hand, it was disconcerting to observe the little attention given to teaching laboratories. Besides teaching their own students, the School of Microbiology is tasked with teaching microbiology and parasitology to a wide array of undergraduate students including medicine, nursing, dentistry, and pharmacy students. Therefore, another important recommendation made to the school was to implement a university-wide biosafety training program mandatory for all those students as well as other training opportunities for a variety of stakeholders both inside and outside the university. As expressed by a participant in one training session, "There are many opportunities for instilling basic biosafety principles in a variety of students, professionals, and administrators, and the rewards for doing so are endless. If we work together, we can all be safer." It is well known that in Cuba, individual researchers first, and a research institute later, were essential in spearheading a national biosafety movement (Fernández et al., 2002). High hopes exist that in Honduras this important role belongs to UNAH.

Similarly, there is optimism that scientific research in the country is becoming a point of interest among policymakers and government officials. Through its Health Minister representing the country at the Council of Ministers of Health of Central America (COMISCA), Honduras has recently recognized the role of research and science as a tool for development and, along with other countries in Central America and the Caribbean, is committed to the “establishment and strengthening of national systems for health research, so as to increase the production and utilization of research activities that address health needs, equity, and development of the countries of the Subregion” (COMISCA, 2009). In light of this commitment, it is anticipated that a concerted effort will hopefully entail strengthening of the several pillars of health research, including biosafety.

Opportune to this progress, the present collaboration (part of a 5-year project aiming to strengthen Honduras’ capacity to do research on and respond to infectious and zoonotic diseases) has brought to UNAH, the largest academic institution in the country, the opportunity to advance in the area of biosafety so it can, by developing the appropriate expertise, fulfill its mandate to be directly involved in biosafety and biosecurity issues. Mandate and expertise are two of the three characteristics for a successful multi-stakeholder partnership identified in the recent declaration by the International Federation of Biosafety Associations (IFBA) for the global advancement of biosafety and biosecurity (IFBA, 2011).

With the experience gained, UNAH is now ready to leverage national and international cooperation to help crystallize its nascent culture of biosafety. Additionally, UNAH has the potential to become a key player in the area of biosafety in the country since considerable efforts are already taking place at the central level. For instance, with major support from the Pan American Health Organization, the National Laboratory Network has upgraded biosafety practices at various virology laboratories and published in 2010 its first Biosafety Manual for Clinical Laboratories. Harmonization of efforts between UNAH and the Ministry of Health with active collaboration of professional associations such as the colleges of microbiologists and laboratory technologists would yield significant results that may certainly have national and Central American impact. Such partnership has already proven extremely successful in Argentina, where the implementation of several coordinated strategies since the early 1990s has resulted in a country-wide enhancement of biosafety practices worth replicating in other developing countries (Lucero et al., 2005).

At the national level, Honduras would benefit greatly from implementing a systematic and participatory process leading to the establishment of national biosafety regulations. Arguably, regulations per se will not guaran-
Continued leadership and national and international support over a period of more than 25 years has converted Cuba into one of the finest models for biosafety in Latin America. During almost the same period, national legislation and multi-partner coordination has contributed to Argentina’s exemplary culture of biosafety. With the current globalization trends, however, neither the developing countries weak on biosafety nor the countries that might be affected by such weakness can afford to wait a quarter of a century for acceptable levels to be reached. The time has come for Honduras to take action and strengthen biosafety and biosecurity practices for its own and the global good. In the complex network of numerous partners, stakeholder UNAH, with its new Biosafety Training Center, seems to be well suited to play an agglutinating function and a fundamental role in capacity building.

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References


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**Guidelines for Safe Work Practices in Human and Animal Medical Diagnostic Laboratories: Recommendations of a CDC-convened, Biosafety Blue Ribbon Panel**

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**Supplements**


[www.cdc.gov/mmwr/pdf/other/su6101.pdf](http://www.cdc.gov/mmwr/pdf/other/su6101.pdf)

Summary

Prevention of injuries and occupational infections in U.S. laboratories has been a concern for many years. CDC and the National Institutes of Health addressed the topic in their publication *Biosafety in Microbiological and Biomedical Laboratories*, now in its 5th edition (BMBL-5). BMBL-5, however, was not designed to address the day-to-day operations of diagnostic laboratories in human and animal medicine. In 2008, CDC convened a Blue Ribbon Panel of laboratory representatives from a variety of agencies, laboratory organizations, and facilities to review laboratory biosafety in diagnostic laboratories. The members of this panel recommended that biosafety guidelines be developed to address the unique operational needs of the diagnostic laboratory community and that they be science based and made available broadly. These guidelines promote a culture of safety and include recommendations that supplement BMBL-5 by addressing the unique needs of the diagnostic laboratory. They are not requirements but recommendations that represent current science and sound judgment that can foster a safe working environment for all laboratorians.

Throughout these guidelines, quality laboratory science is reinforced by a common-sense approach to biosafety in day-to-day activities. Because many of the same diagnostic techniques are used in human and animal diagnostic laboratories, the text is presented with this in mind. All functions of the human and animal diagnostic laboratory—microbiology, chemistry, hematology, and pathology with autopsy and necropsy guidance—are addressed. A specific section for veterinary diagnostic laboratories addresses the veterinary issues not shared by other human laboratory departments. Recommendations for all laboratories include use of Class II A2 biological safety cabinets that are inspected annually; frequent hand washing; use of appropriate disinfectants, including 1:10 dilutions of household bleach; dependence on risk assessments for many activities; development of written safety protocols that address the risks of chemicals in the laboratory; the need for negative airflow into the laboratory; areas of the laboratory in which use of gloves is optional or is recommended; and the national need for a central site for surveillance and nonpunitive reporting of laboratory incidents/exposures, injuries, and infections.