Research article

Variation in Storage Temperatures for Foot and Mouth Vaccine in Cambodia

SOCHEAT SIENG*
Institute for Rural Future, School of Behavioural, Cognitive and Social Sciences, University of New England, Armidale, New South Wales, Australia
Email: s.socheat2010@gmail.com

STEPHEN W. WALKDEN-BROWN
Animal Science, School of Environmental and Rural Science, University of New England, Armidale, New South Wales, Australia

JAMES KERR
Institute for Rural Future, School of Behavioural, Cognitive and Social Sciences, University of New England, Armidale, New South Wales, Australia

Received 15 December 2015 Accepted 11 July 2016 (*Corresponding Author)

Abstract Vaccine efficacy may be influenced by pre-use storage condition. This study assesses vaccine cold storage management and vaccine handling practices at 30 veterinary drug stores spread across the provinces of Pursat (n=10), Kampong Cham (n=9) and Phnom Penh (n=11) in Cambodia. Electronic data loggers were used to record the temperature in each cold storage facility every thirty minutes for a period of thirty days. The findings indicated that vaccines were exposed to freeze temperature for 24-100 hrs (3%-14%) and more than 100 hrs (15%-87%) of time recordings in 8 and 9 facilities respectively. Vaccines were exposed to heat for 254-327 hrs (35%-45%) of time recordings in 3 facilities and between 468-7200 hrs (65%-100%) in 4 facilities. Most of the refrigerators also contained food and/or drinks, leading to the frequent door opening. Vaccines were often stored in the bottom drawers and door shelves, which were the warmest locations within refrigerators in the study. The vast majority of the study refrigerators (93.3%) were not equipped with a maximum-minimum thermometer. Daily refrigerator temperature recording was not practiced in any of veterinary drugstores. This study also highlighted the considerable temperature fluctuations to which vaccines were exposed to a number of refrigerators. The frequent power failures which occur in Cambodia contribute to these temperature fluctuations. This study consequently also investigated the speed and duration of temperature rise in a cold storage facility during a typical power failure in Phnom Penh. The results suggested that corrective training for vaccine wholesalers/retailers and relevant government staff may be a useful first step in attempting to improve vaccine storage conditions, hence, improved potency. Maintenance of vaccine potency is likely to improve the success of vaccination programs in Cambodia. This critical but neglected issue requires improved practices and ongoing monitoring. The results also highlight the need for improvement and solutions to avoid ongoing future exposure of vaccines to freezing, too cold and too hot temperatures, particularly in hot tropical countries like Cambodia.

Keywords data logger, veterinary drug store, vaccine, vaccine cold storage, Cambodia

INTRODUCTION

Vaccination is a key control method for foot and mouth disease (FMD) in countries where the disease is endemic as is the situation in Cambodia. Immunization is a highly effective way of protecting

individuals and communities from infectious disease. However, successful vaccination campaigns require proper storage, transportation and handling of vaccines, including inactivated FMD vaccines (El-Sayed, El-Din, Rizk, & El-Aty, 2012). The FMD vaccines currently used in Cambodia are inactivated, oil adjuvant purified antigen preparations. Vaccine shelf life is always indicated by the manufacturer and is usually six to twelve months under the specified conditions of storage. Typically these include storage between 2-8 ˚C protected from light and freezing. Typically freezing the vaccine or heating the vaccine will promote emulsion breakdown and destroy vaccine integrity/efficacy over time (S. Seneque, Merial (Asia), personal communication, September 5, 2014). A study by Bell et al., (2001) revealed that failure to keep the thermometer in the vaccine storage facilities was associated with vaccine storage temperatures outside recommended range (2-8 ^{o}C). Cortese and Smith (2004) reported freezing of vaccine will disrupt the integrity of the antigens and degrade the adjuvant and overheating can have the same effect. Incorrect handling or storage of vaccine may result in an ineffective vaccine being administered and failure of protection (Rashid, Rasheed, & Akhtar, 2009). To remain potent, FMD vaccines should be stored under refrigeration usually at 4±2 ^{o}C for the optimal retention of antigenic potency (Garland, 1999) and should not be used if they have frozen or exposed to high temperatures or are outside the use by date (Cortese & Smith, 2004). Weir and Hatch (2004) suggested that never store vaccines on refrigerator-door shelves, where they are often exposed to warm air every time the door opens. The vaccine is thought to lose immunogenic potency progressively as the storage temperature increases above these levels. Thawing frozen vaccines or re-cooling over-heated vaccines does not restore vaccine integrity (Cortese & Smith, 2004) and damages their immunogenicity (Garland, 1999).

When an inactivated oil adjuvant FMD vaccine was stored at 4 ^{o}C for 15 months, no appreciable vaccine potency loss could be detected by the direct challenge testing of vaccinated cattle and specific antibody assay (Doel, 2003; Garland, 1999). Recent research has confirmed that FMD vaccine may keep their potency for two years at 4 ^{o}C, three weeks at 25^{o}C and one week at 37 ^{o}C with full protection against challenge with FMDV O1/Aga/EGY/93 (El-Sayed et al., 2012). Protection was decreased to 80% when vaccines were stored at 25 ^{o}C for 4 weeks and at 37 ^{o}C for 2 weeks. The efficiency of the cold chain is, therefore, a critical factor for optimal vaccine storage (Garland, 1999). Farmer interviews during the 2010 FMD outbreak in Cambodia suggested very poor protection of cattle in responses to vaccination administered by government authorities in Kampong Cham province. The major reasons for this failure were thought to be poor planning, timing and implementation of the vaccination program, as well as improper vaccination technique (under-dosing) and weaknesses in the vaccine cold chain (Sieng & Kerr, 2013). The donated FMD vaccine used was reported not to have been stored at the proper temperatures recommended by the manufacturer (District veterinarians and village animal health workers, personal communication, October 30, 2010). These allegations require proper testing as temperature in vaccine cold storage facilities in Cambodia have not previously been investigated and reported. Consequently, this study represents is first attempt to measure the performance of government and commercial vaccine cold storage facilities in three regions of Cambodia.

OBJECTIVE

In this study we aimed to investigate vaccine storage temperatures in veterinary drug stores in two Cambodian provinces and in the capital city of Phnom Penh.

METHODOLOGY

The main study (Study 1) design involved continuous monitoring of temperatures for 30 days at 30 veterinary drugstores (VDs) spread across the provinces of Pursat (PS, n = 10), Kampong Cham (KC, n = 9),

and the capital Phnom Penh (PP, n = 11). All known eligible VDs in the 3 areas was invited to participate based on selection criteria including significant vaccine sales and willingness to participate. The study sites included predominantly vaccine retailers but also government vaccine stores of the study sites. In KC almost all vaccine stores in Prey Chhor district (3) and Kampong Cham provincial town (6) participated in the study. In PS province, six (6) VDS participated in Sampov Meas district, as well as four (4) from Bakan district. Eleven (11) stores in PP participated in the research study. A total of thirty refrigerators in 30 VDs located in 3 areas in Cambodia were thus selected for the study. Of these thirty VDs, 3 were government cold storage facilities, and 27 were vaccine retailers. Of the 27 VDs, 26 used a domestic type refrigerator and one used a cold-box. Two out of 3 government cold storage facilities used domestic type refrigerator and one (PP) involved a large refrigerated vaccine storage facility. Temperature recording was via electronic data loggers[1] (Thermochron®), programmed to record temperatures at 30 minute intervals for 30 days, a total of 1,440 readings for each refrigerator. The recording accuracy was ±1 ^{o}C. The performance of the data loggers was tested in a refrigerator with a known temperature as demonstrated by a thermometer. The precise date of placement of the data loggers was unknown to participants until immediately before placement. A single data logger was placed centrally in the refrigerator or cold box next to vaccines but not placed immediately beside or on an ice pack or ice. The VDs were visited every week by research assistants to ensure that the data logger was still in the same position. Each half-hourly temperature recording was classified as 'freezing' (≤ 0 ˚C), 'too cold' (> 0 but < 2 ˚C), 'recommended range' (2-8 ˚C) or 'too hot' (> 8 ˚C) and the proportion of samples in each category determined for each data logger.

These data were analyzed within temperature categories by one way analysis of variance (AOV) to test the effect of province (and the reliability of its power supply) on the proportion of samples in each category. A separate dataset was created in which the duration of each period spent within each temperature category over the 30 days experimental period was recorded. This enabled analysis of the mean time spent in each temperature category. This was repeated measures analysis so a mixed restricted maximum likelihood (REML) model was fitted with data logger as a random effect and province, temperature category and their interaction fitted as fixed effects. Analyses were performed using JMP 12[2] with a statistical significance level of $P < 0.05$. Because power failures are a frequent and sometimes prolonged event in Cambodia, an additional small study was carried out to test the effect of a power failure on temperatures within a vaccine storage facility (Study 2). The study used the data loggers and ran for a period of 18 days. The government vaccine cold storage facility in Phnom Penh was chosen for this study because the presence of a 24 hour guard at that facility allowed accurate recording of the time that the electricity blackout began and ended, so that these times could be matched with the temperatures recorded by the data loggers inside the vaccine cold storage facility during the same period. The effect of location within a refrigerator on temperature variability was also investigated in a VD in Phnom Penh (Study 3). The study was carried out for a period of 30 days by using the same data loggers.

RESULTS AND DISCUSSION

At the completion of study period for Study 1, we received 30 completed data loggers, giving an overall successful recording rate of 100. Table 1 summarizes the performance of each refrigerator during the 30 day study period, including mean, median, maximum and minimum temperatures recorded and time spent in each of the four temperature categories: 'freezing' (≤ 0 ^{o}C), 'too cold' (> 0 but < 2 ^{o}C), 'recommended range' (2-8 ^{o}C) and 'too hot' (> 8 ^{o}C). The final column in table 1 titled

[1] *Thermochron® DS1921, Dallas Identification/ALFA-TEK Australia, 7/42-50 Stud Road, PO Box 882, Bayswater, VIC. 3153, Australia*
[2] *JMP version 12 (SAS Institute Inc., NC, USA, 2015)*