Letter

Research letter

How to eliminate scabies parasites from fomites: A high-throughput ex vivo experimental study

To the Editor: Scabies is one of the most prevalent infectious dermatologic diseases worldwide.[1] Overcrowding, high population movement, and suboptimal health care are major risk factors for outbreaks, particularly in disadvantaged populations and institutional settings. In the tropics, scabies often causes secondary bacterial infections and potentially life-threatening sequelae including sepsis, glomerulonephritis, rheumatic fever, and heart disease. Direct skin-to-skin contact is the main transmission pathway; however, as mites survive short term outside their host, contaminated fomites can also spread the disease,[2] especially in the cases of profuse or crusted scabies. Parasites within skin squames shed into bedding have been reported to infect laundry workers[3] and have been responsible for therapeutic failure. Consequently, environmental decontamination should be integrated with individual medication. To date, to our knowledge, no field studies have been performed to validate decontamination measures. Because there is no in vitro culture, previous experimental research was limited to parasite numbers and never considered the egg stage. Accordingly, the existing decontamination protocols are based on poor statistical power and vary significantly, resulting in confusion for patients and medical workers. We aimed to generate statistically valid experimental data as a basis for developing standardized guidelines with clear and simple directions for scabies outbreaks.

More than 5500 adult mites and 2300 eggs of *Sarcoptes scabiei* were obtained from a porcine model,[4] exposed to 89 different conditions, and individually monitored in custom-designed wire mesh pouches (see Supplemental Video; available via Mendeley at https://doi.org/10.17632/gpc3rzsrdd.1) in experimental groups of 20 to 25. Initial in vitro mite survival and egg-hatching assays (Supplemental Table 1; available via Mendeley at https://doi.org/10.17632/gpc3rzsrdd.1) informed subsequent real-life ex vivo experiments (Fig 1 and Supplemental Table 2; available via Mendeley at https://doi.org/10.17632/gpc3rzsrdd.1), resulting in a simple strategic flowchart for decontamination (Fig 2).

We determined the thermal killing point (ie, 100% of scabies mites and eggs were dead) as 50°C or greater if exposed for at least 10 minutes. Accordingly, washing or heat drying beyond this threshold in conventional machines killed parasites quickly (Fig 1). Detergent or ozone laundry disinfection, known to rapidly eliminate single-cell pathogens, had minimal effect on mite and egg mortality. Freezing below -10°C for at least 5 hours is another safe option for killing mites and eggs (Fig 1). For people with limited access to electricity, hot water, and household appliances, isolating scabies-contaminated fomites until all parasites are dead is a valid but prolonged option (Fig 1). The time of effective isolation varies between a minimum of 3 days in temperate-dry and a maximum of 8 days in warm-humid conditions.

It is very difficult to sample intact scabies parasites from human patients. *S scabiei* biovars isolated from human or pig are phenotypically indistinguishable, and some human biovars are genetically closer to porcine than to coinfesting human biovars isolated from the same patient.[5] We reason that extrapolation of our results to human scabies management is valid. Because of the labor-intensive nature of the experiments, we limited this study to the most applicable procedures. Hot steam, ironing, or sunlight could be trialed, and differentiation between the effects of temperature and humidity could be resolved. Nonetheless, this foundational exploration forms the essential basis for informed recommendations.

This study was conceived in response to community requests to establish optimal decontamination conditions for scabies infested textiles. We were approached by indigenous community representatives located in remote Queensland, Australia, and by Orange Sky Australia, a nonprofit organization based in Brisbane, running a mobile laundry service to improve hygiene standards and promote skin health awareness in remote Australia. Orange Sky provided access to their washing machines and ozone laundry system to carry out some of the experiments described here.

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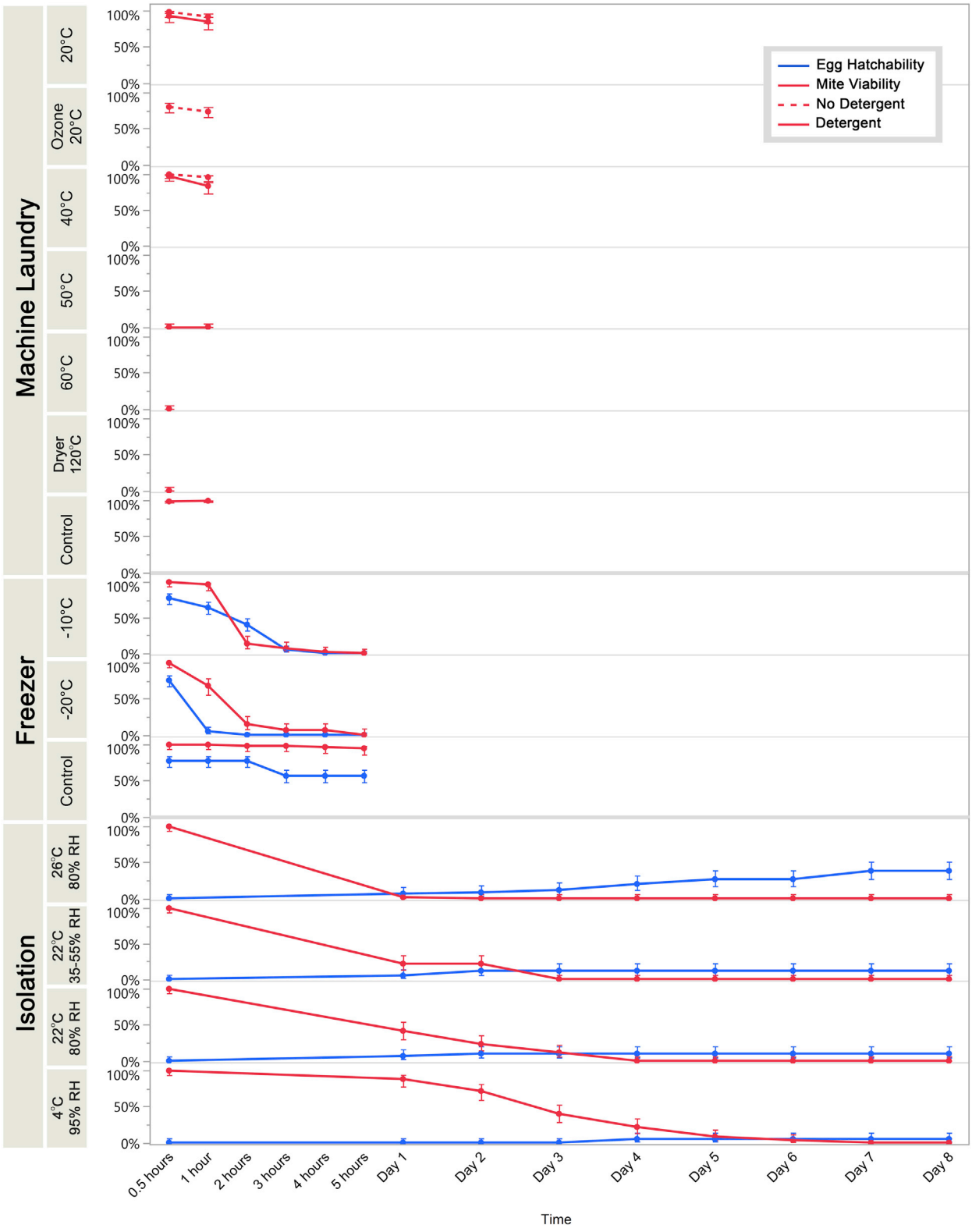

Fig 1. Viability of *Sarcoptes scabiei* observed over time when exposed to different methods of machine decontamination. The upper panel shows the percentage of mite viability observed when using a conventional washing machine at 4 different temperatures for 30 and 60 minutes, with or without detergent. Ozone treatment at 2 to 4 parts per million in unheated water was tested in an industrial grade washing machine for 30 and 60 minutes. Heat drying at a high

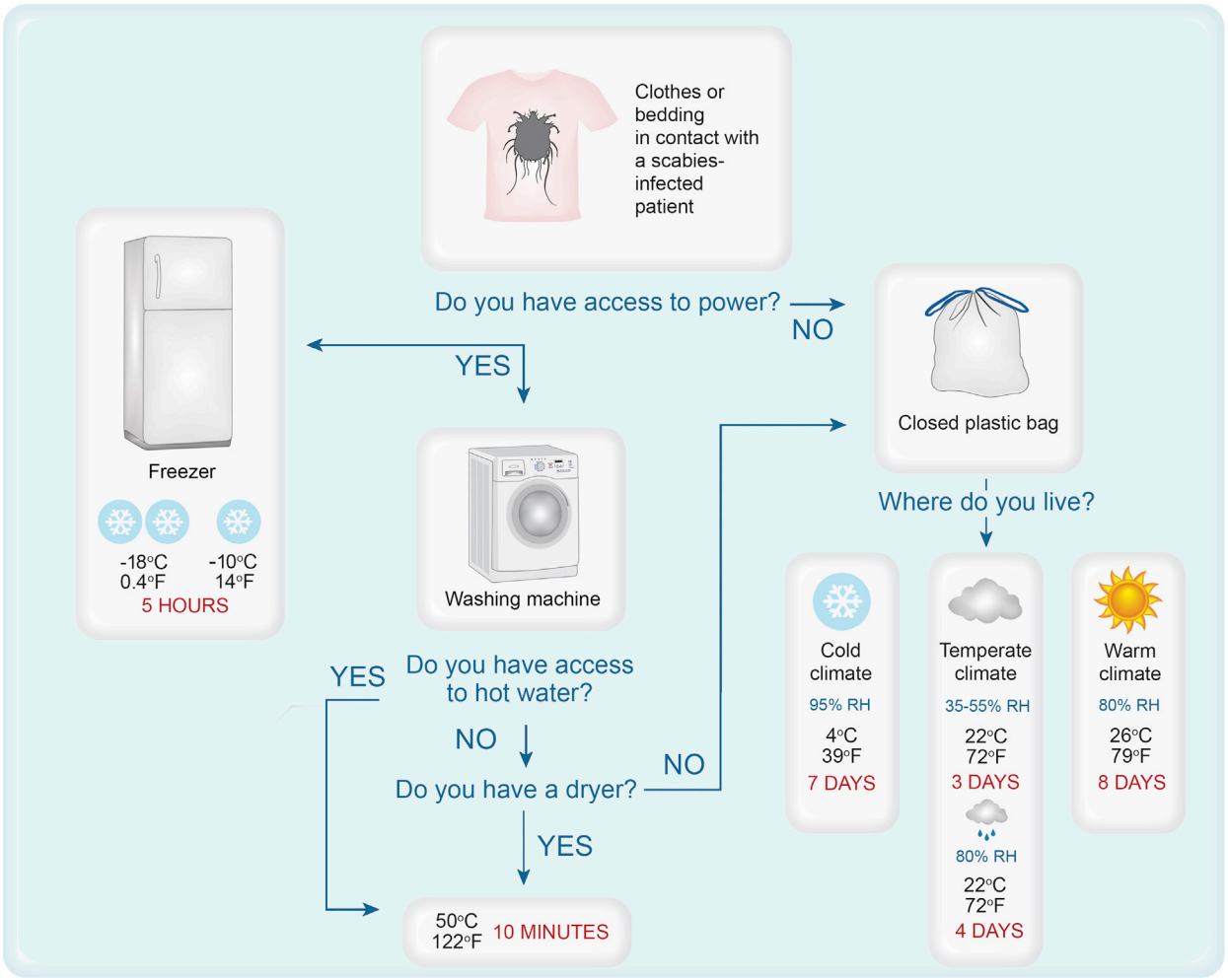

Fig 2. Flow chart outlining the proposed strategies for the environmental control of human scabies. *RH*, Relative humidity.

the logistics of the laundry-washing experiments. We thank Professor D. McManus, Professor S. Sriprakash, and Dr L. Cascales for critically reading the manuscript.

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setting in a conventional laundry dryer was tested for 30 minutes. The middle panel shows the percentage of mite viability and eggs hatched when freezing at 2 different temperatures from 0.5 to 5 hours. The lower panel shows the percentage of viable mites and percentage of eggs hatched over 8 days in isolation at different temperatures and humidity levels. The error bars represent 95% binomial confidence intervals for each time point. Statistical analyses were performed using JMP Pro, version 15.0.0 (SAS Institute, Cary, NC). *RH*, Relative humidity.

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