ORIGINAL SCIENTIFIC PAPER

SHORT REPORT

Personal medicines storage in New Zealand

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ABSTRACT

INTRODUCTION: Poor storage of medicines can reduce their efficacy, yet little is known about how people store medicines in their homes and elsewhere, why these locations are chosen, and whether the conditions are suitable for medicines storage.

AIM: To investigate where medicines are commonly stored in New Zealand households, why, and the typical conditions—temperature and relative humidity—in those places of storage.

METHODS: Data from a large qualitative study on the meanings of medicines were analysed to explore where people store medicines in their households, and why. A data logger was used to log temperature and relative humidity in common medicine storage places, such as homes and cars.

RESULTS: Kitchens and bathrooms were the most commonly reported storage places, with people influenced by convenience, desire to remember to take medicines, and child safety when deciding where to store medicines. High temperatures and humidity were found in kitchens and bathrooms, extreme temperatures in a car and a backpack, and extremely low temperatures in checked-in luggage on a plane.

DISCUSSION: Temperature- and humidity-sensitive medicines should not be stored long-term in common storage locations, such as kitchens and bathrooms. Conditions in these places may not comply with the recommended storage conditions given by the manufacturer. Furthermore, medicines should not be left in backpacks or cars, especially if the vehicle is in the sun. Medicines that may degrade upon freezing and thawing—such as protein-containing medicines, emulsions, suspensions and some solutions—should not be stored in the cargo hold of a plane.

KEYWORDS: Drug storage; humidity; New Zealand; temperature

Introduction

Appropriate storage is essential to ensure the safety, quality and efficacy of medicines. However, apart from a few studies in developing countries,[1–4] there is little research on where people store medicines and why, and the conditions in these common locations.

The shelf life of a medicine established by a manufacturer only applies when products are stored under conditions outlined on the label.[5] According to guidelines, medicines should also be stored out of reach and sight of children, in order to prevent unintentional poisonings.[6,7] Medicines should be stored in their original packaging. Medicines to be stored at room temperature should be kept in a well-ventilated place, between 15 and 25°C, or up to 30°C, depending on climatic zone.[8]

Temperature greatly influences medicine degradation chemically, physically and microbiologically. Chemical degradation, such as oxidation or hydrolysis, increases with temperature, often exponentially.[9] Physical degradation occurs at both high and low temperatures, and may be irreversible. Proteins may denature and aggregate at high temperatures, or because of freezing. Emulsions can crack and, in solutions, medicines may precipitate at low temperatures and particles in suspensions may grow, making them hard to re-suspend upon shaking.[9,10]

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Moisture can also be a problem for medicine stability. Exposure to high humidity increases chemical degradation of water-labile medicines and excipients, for example cellulose.[11] All plastics used in medicine packaging are somewhat permeable to water vapour. Moisture also promotes the growth of microbes,[11] particularly in hot conditions (e.g. greater than 30°C and 75% relative humidity).

Studies in other settings have found problems with medicines storage. Temperatures in emergency medical vehicles, such as helicopters and ambulances, were found to exceed recommended storage conditions on hot days,[12,13] as did those in a doctor's bag in two cars.[10] This study was undertaken to investigate where people in New Zealand store their medicines and why, and to describe the conditions (temperature and relative humidity) in such places.

WHAT GAP THIS FILLS

What we already know: Excessive heat and humidity can damage medicines and reduce their efficacy. Studies in developing countries and in health care settings have shown that storage conditions are sometimes suboptimal.

What this study adds: People in New Zealand often store medicines in kitchens, bathrooms, and also sometimes store them in cars and carry them in bags. For convenience, and in order to remember to take their medicines, New Zealanders often store medicines in places where excessive heat and humidity may cause problems with medicines.

Methods

Personal medicine storage in households

Data from the ongoing project *Medications in Everyday Life: Understandings and Social Practices* was used to investigate where people store their medicines and why. Transcripts of 36 household interviews that included questions about medicines used and where they were stored, and maps and photographs of storage locations were used. Households were located in four cities in New Zealand. The study methods are further described elsewhere.[14] Information relevant to medicine storage locations and reasons for these locations was extracted from transcripts. A count of how many rooms in each household had medicines in them was produced from the household maps.

Personal medicine storage conditions

Two data loggers (Hobo U10 Temperature Relative Humidity Data Logger, U10-003 and H8-001-02. Onset Computer Corporation, Cape Cod, USA) were placed in six different locations that were identified as common storage places (but not in the households in the *Medications in Everyday Life* study). Three kitchens, two bathrooms and one bedroom were used; three in Dunedin and three in Palmerston North. The duration of placement varied from one day to six days. Measurements were taken every 10 to 15 minutes. Since many of the participants in the first part of the study mentioned forms of mobile storage of medicines, such as handbags and cars, data loggers were also placed in a backpack in the sun in Dunedin, two cars in Dunedin, and suitcases in the cargo hold of planes flying from Dunedin to Christchurch, Palmerston North, and Copenhagen.

Results

Medicine storage in households

Participants were 104 people (40% men and 60% women), with an average age of 34 years. A range of ages, ethnic groups and households of different sizes and composition were included. The kitchen was the most common location in the house for storage of medicines (33 households had medicine in the kitchen), followed by the bathroom (21 households) and the bedroom (19 households). Forms of mobile storage, such as handbags and backpacks were also common (18 households). Other storage locations included a car glove box, under a mattress, and in a garage. The average number of rooms where medicines was stored per household was three.

Reasons given for storage decisions included: convenience, as a cue to remember to take them, and safety of children. Many participants said they stored their medicines in particular locations because of convenience. This was often based on their daily routine and where they would be when the medicines needed to be taken.

Medicines to be consumed with food were often stored in particular locations in the kitchen to make them convenient to take at a meal time. Medicines needed to be taken first thing in the morning were stored in the bedroom.

Placement of medicines was often used as a cue to remember to take them. Many people put medicines in a place that was part of their daily routine in order to be reminded to take them.

Studies in other settings have found problems with medicines storage. Temperatures in emergency medical vehicles, such as helicopters and ambulances, were found to exceed recommended storage conditions on hot days, as did those in a doctor's bag in two cars.

For most households with children, storing medicines out of children's reach was also an important consideration. Few households mentioned temperature or humidity as considerations in medicine storage.

The use of some form of intermediary storage was common, such as putting the next dose of a medicine into another container in preparation for consumption. This both reminded them to take the medicines, and allowed them to check whether they had taken them. Some people mixed several medicines together to create a homemade daily or weekly medicine dispenser.

Medicine storage conditions

Table 1 presents the temperature and relative humidity (RH) results for the household locations studied. Although the mean conditions of all the storage places studied were similar, the maximum and minimum conditions differed markedly. Kitchens had the highest maximum temperature, and bathrooms had the highest maximum humidity. The bedrooms had relatively constant temperature and humidity conditions.

Table 2 shows the conditions in mobile storage locations. Temperatures in the backpack rose above 60°C after only around 20 minutes in the sun around midday. The storage temperature reached 54.5°C in one of the cars when in the sun. The study was carried out on mild Dunedin summer days.[15,16]

Although the temperature of the data logger did not drop very much during the flights to Christchurch and Palmerston North (possibly because of clothing acting as insulation), on the long sequence of flights from Dunedin to Copenhagen, the temperature dropped to -3.32°C.

Table 1. Temperature and relative humidity (RH) in different household locations and outside temperatures for the same time period

		Temperature and humidity °C (RH)			Outside temperature °C	
City	**Location**	**Maximum**	**Minimum**	**Mean**	**Maximum**	**Minimum**
Palmerston North	Bathroom	31.5 (100)	20.6 (33.0)	23.6 (47.1)	22.4	10.9
Dunedin	Bathroom	26.0 (95.0)	13.8 (51.4)	18.4 (70.2)	20.0	14.7
Dunedin	Bedroom	23.5 (69.2)	18.8 (50.1)	21.7 (59.2)	22.2	8.6
Palmerston North	Kitchen (cabinet)	27.1 (85.2)	18.7 (36.2)	21.9 (47.2)	20.2	11.5
Palmerston North	Kitchen (above the oven)	32.8 (57.5)	18.7 (27.2)	23.5 (45.0)	23.5	13.5
Dunedin	Kitchen	36.3 (81.6)	16.0 (34.5)	21.0 (68.2)	24.9	14.8

Table 2. Storage conditions in mobile storage and outside temperatures for the same time period

		Temperature and humidity °C (RH)			Outside temperature °C	
City	**Location**	**Maximum**	**Minimum**	**Mean**	**Maximum**	**Minimum**
Dunedin	Backpack (in sun)	67.3 (51.5)	18.0 (15.0)	36.4 (22.1)	21.8	9.5
Dunedin	Car (silver colour)	42.5 (75.7)	14.2 (15.0)	24.3 (40.7)	21.5	15.9
Dunedin	Car (dark green colour)	54.5 (66.1)	7.1 (15.0)	19.7 (46.4)	17.8	11.8
Dunedin to Christchurch and return flights	Suitcase (cargo hold of plane)	26.1 (70.4)	22.1 (63.1)	24.2 (66.6)	–	–
Dunedin to Palmerston North and return flights	Suitcase (cargo hold of plane)	25.6 (49.3)	14.5 (34.2)	20.4 (42.1)	–	–
Dunedin to Copenhagen and return flights	Suitcase (cargo hold of plane)	23.4 (63.8)	-3.3 (42.0)	15.0 (52.0)	–	–

Discussion

Few people in this study mentioned temperature or humidity as considerations in where to store their medicines. Our study suggests that medicines may be stored in unsuitable places. Kitchens and bathrooms are likely to be unsuitable places for long-term storage of medicines, and cars and bags left in the sun can reach extremely high temperatures. These can rapidly lead to significant chemical and physical degradation of medicines.[10] Protein-containing products are especially prone to degradation at temperature extremes, with insulin—especially in the rapid-acting solution form—potentially almost completely denaturing within hours at the observed maximum temperature.[17] Very high temperatures, such as those of the backpack (above 60°C), may also affect the integrity of the packaging of the medicines.[12]

The extremely low temperatures of checked luggage on aeroplanes could affect the physical stability of some liquid preparations, such as solutions, suspensions and emulsions. If temperatures became sufficiently cold for protein-based formulations to freeze, this would very likely lead to protein denaturation.[10]

In the first part of the study, data from a small, non-random sample of participants was used. This was sufficient to generate ideas about where people store medicines and why, but results should be interpreted with caution and a larger quantitative study would be needed if it was important to establish population rates for each storage location or reason. The number of storage locations that were studied was limited and the duration of the study was short, therefore the storage conditions measured in the studied locations may not be typical.

We recommend that temperature- and humidity-sensitive items should not be stored long-term in kitchens and bathrooms. Medicines, especially protein-based medicines, should not be stored in bags or cars for any longer than strictly necessary, and care should be taken to keep these out of the sun. Medicines susceptible to freezing—such as emulsions, solutions and suspensions—should not be stored in the cargo hold of a plane on long flights. Health care professionals, particularly pharmacists, should advise people where to store medicines, in order to ensure their safety, quality and efficacy, and poor storage should be considered as a possible cause when medicines are not providing the desired effect. More research is

needed, in a wider variety of locations, to establish whether conditions in usual storage locations actually reduce the effectiveness of medicines. This should focus on high-risk medicines, such as insulin, and be used to guide a broader public education campaign about medicines storage.

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COMPETING INTERESTS
None declared.